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Devreese et al.

(10) **Patent No.: US 11,247,548 B2**
(45) **Date of Patent: Feb. 15, 2022**

(54) **MODULAR HEAD ASSEMBLY FOR AN ELECTRIC AXLE**

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(21) Appl. No.: **16/500,010**

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§ 371 (c)(1),
(2) Date: **Oct. 1, 2019**

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PCT Pub. Date: **Nov. 29, 2018**

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(51) **Int. Cl.**
F16H 57/02 (2012.01)
B60K 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B60K 1/00*** (2013.01); ***B60B 35/14*** (2013.01); ***B60B 35/163*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. B60K 1/00; B60K 17/165; B60K 2001/001; B60K 17/354; B60K 17/356;
(Continued)

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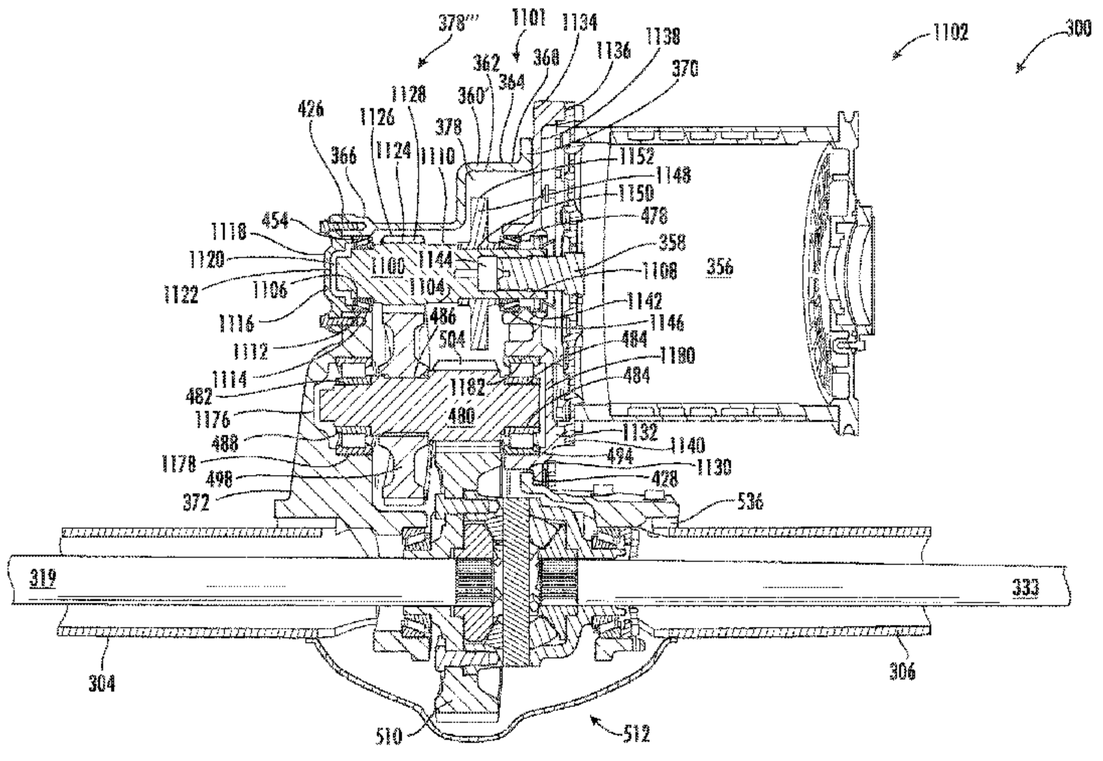
Primary Examiner — Justin Holmes
(74) *Attorney, Agent, or Firm* — McCoy Russell LLP

(57) **ABSTRACT**

A modular electric axle head assembly for a vehicle. An axle assembly of the vehicle includes a banjo portion with a first opening extending from an inner surface to an outer surface of an inboard side of the banjo portion. At least a portion of a differential assembly disposed within at the banjo portion of the axle assembly and is drivingly connected to at least a portion of a gear assembly. The gear assembly is also
(Continued)



drivingly connected to a motor output shaft. At least a portion of the gear assembly is disposed within a hollow portion of a gear assembly housing. An outboard portion of the gear assembly housing has a mounting flange that is integrally connected to the inboard side of the banjo portion. A first and second protruding portion extends from the axle assembly mounting flange and provides rotational support for the differential assembly.

22 Claims, 18 Drawing Sheets

(51) **Int. Cl.**

B60B 35/14	(2006.01)
B60B 35/16	(2006.01)
B60K 17/16	(2006.01)
B60T 1/06	(2006.01)
F16H 37/08	(2006.01)
F16H 57/021	(2012.01)
F16H 57/029	(2012.01)

(52) **U.S. Cl.**
CPC ***B60K 17/165*** (2013.01); ***B60T 1/062*** (2013.01); ***F16H 37/08*** (2013.01); ***F16H 57/02*** (2013.01); ***F16H 57/021*** (2013.01); ***F16H 57/029*** (2013.01); *B60K 2001/001* (2013.01); *F16H 2057/02034* (2013.01); *F16H 2057/02052* (2013.01)

(58) **Field of Classification Search**
CPC B60K 17/36; B60K 17/346; B60B 35/14; B60B 35/163; B60B 35/16; B60T 1/062; F16H 37/08; F16H 57/02; F16H 57/021; F16H 57/029; F16H 2057/02034; F16H 2057/02052; F16H 2048/423; B60Y 2200/1422; B60Y 2200/91; B60Y 2200/92
See application file for complete search history.

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FIG. 1

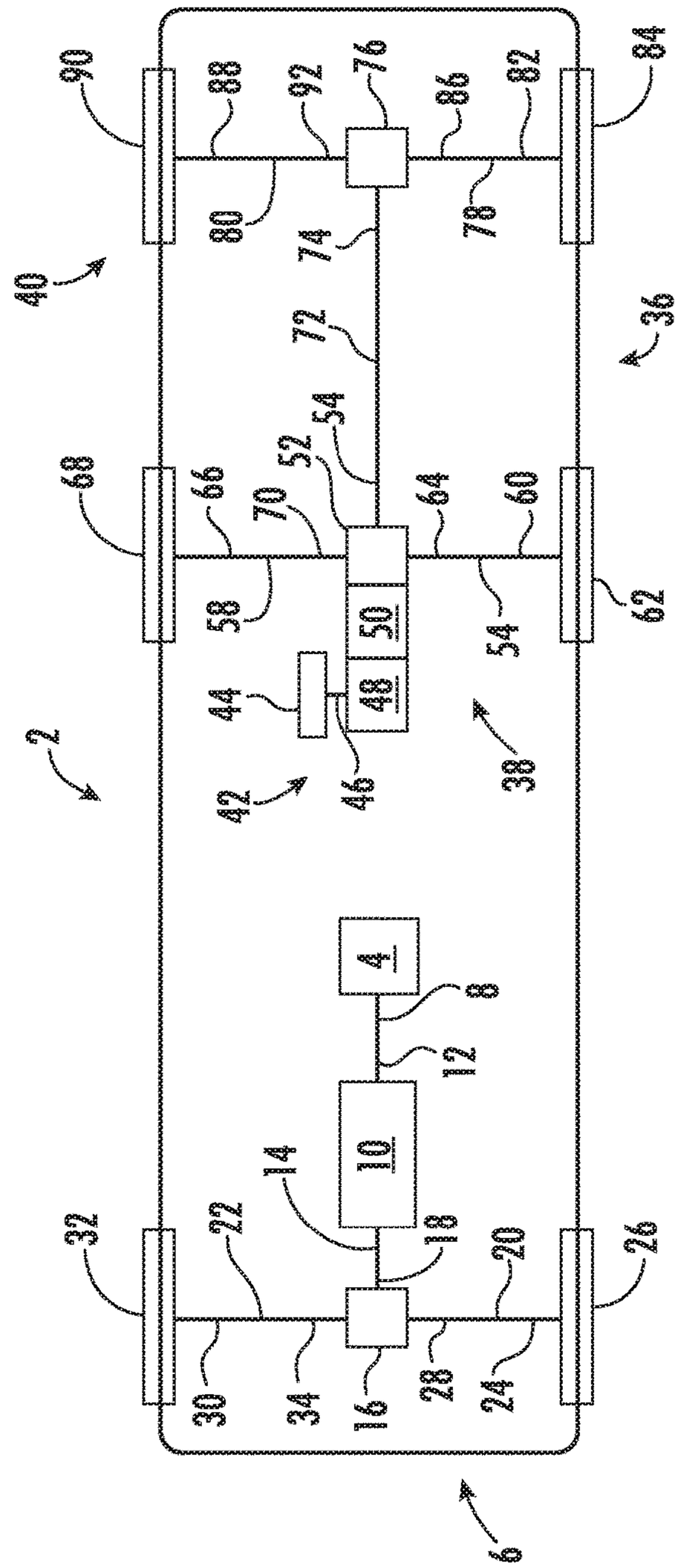
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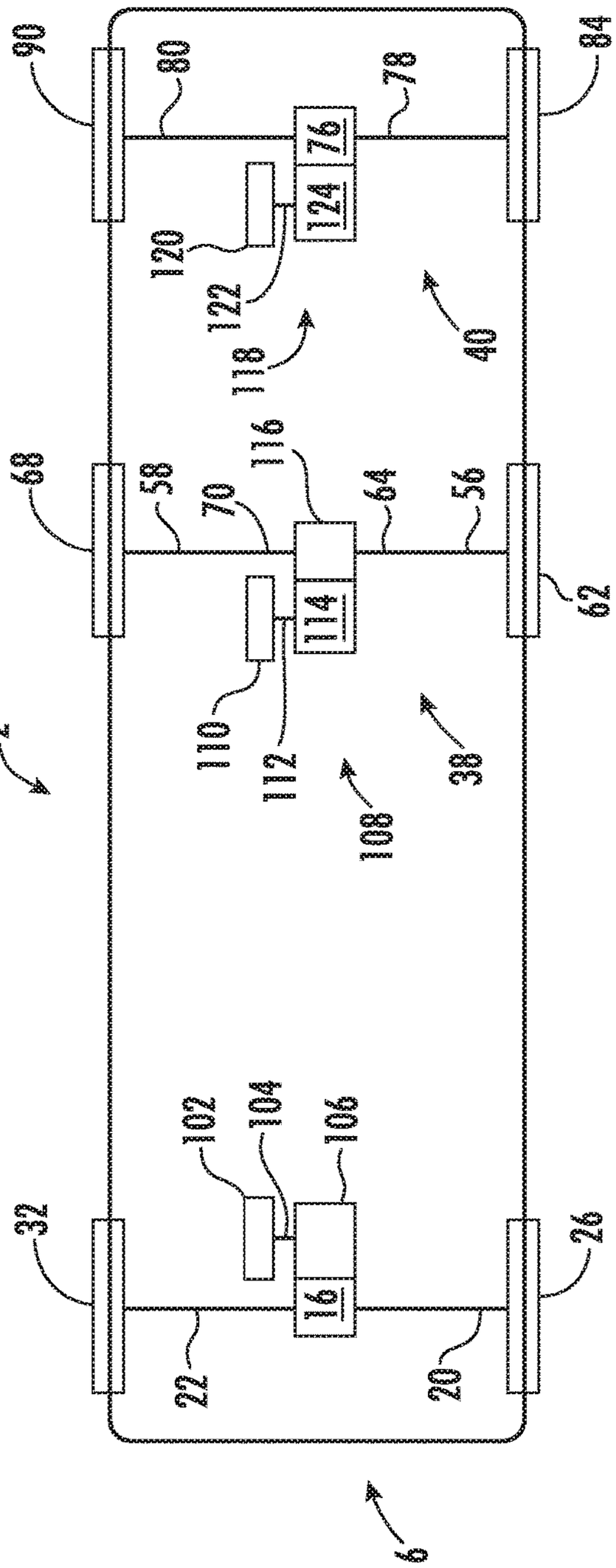
FIG. 2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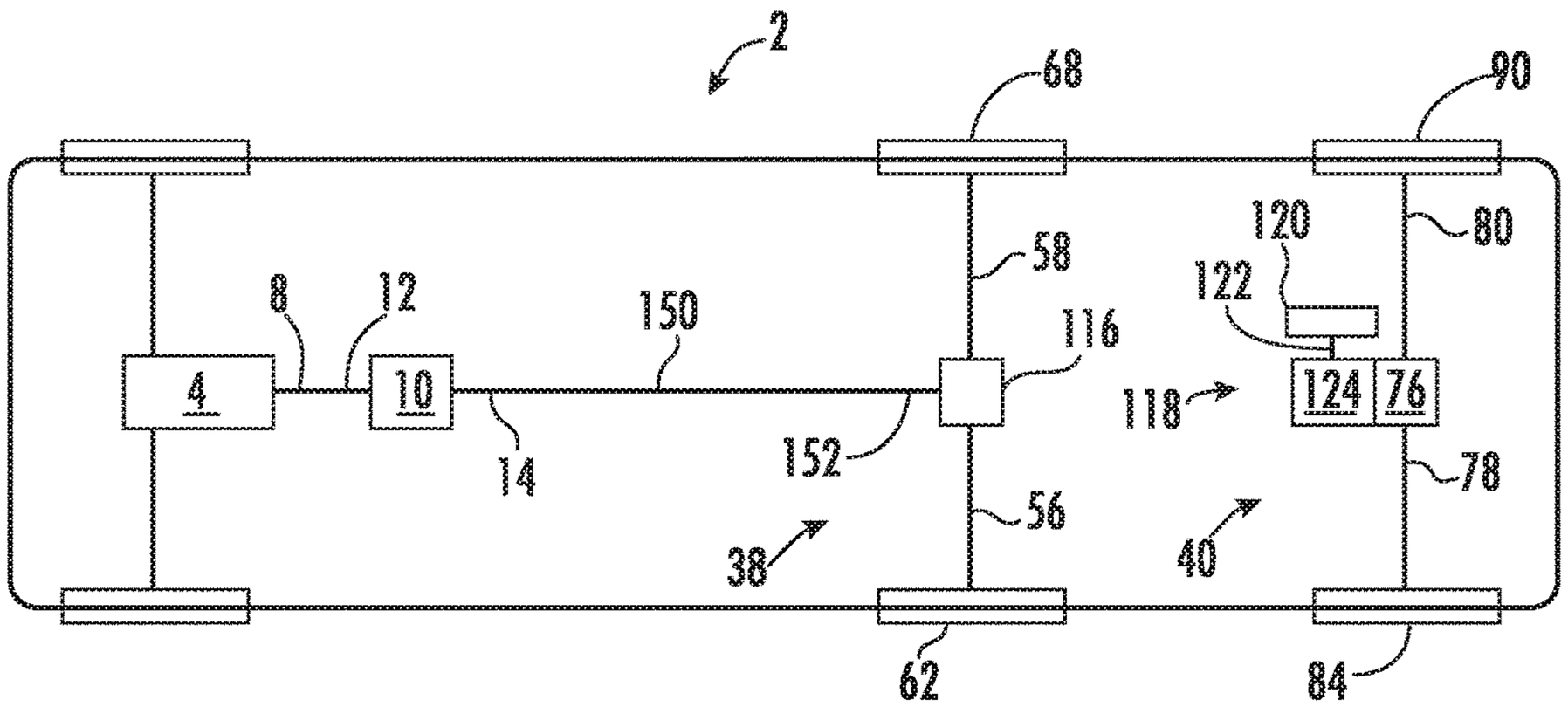

FIG. 3

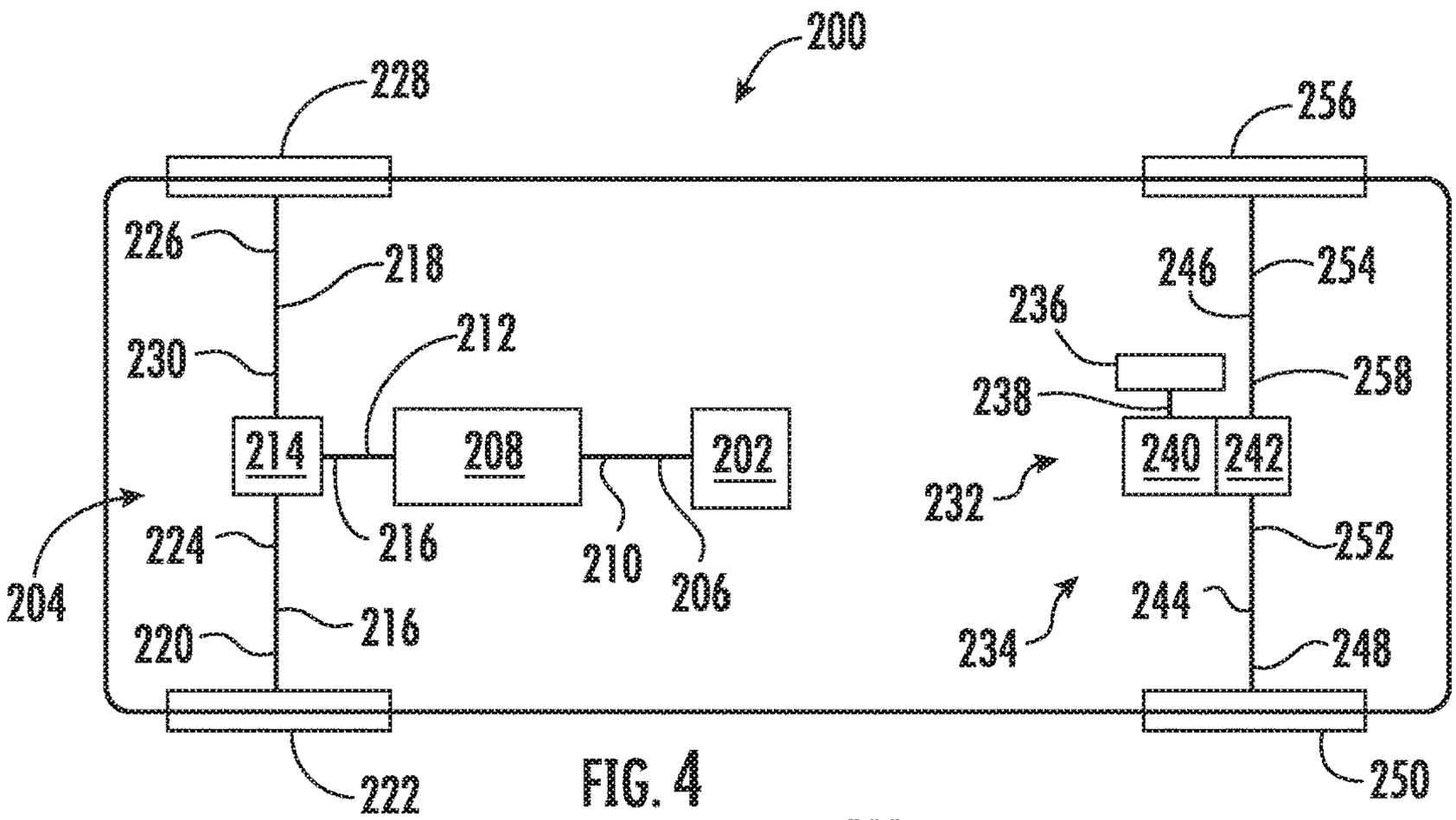

FIG. 4

FIG. 5

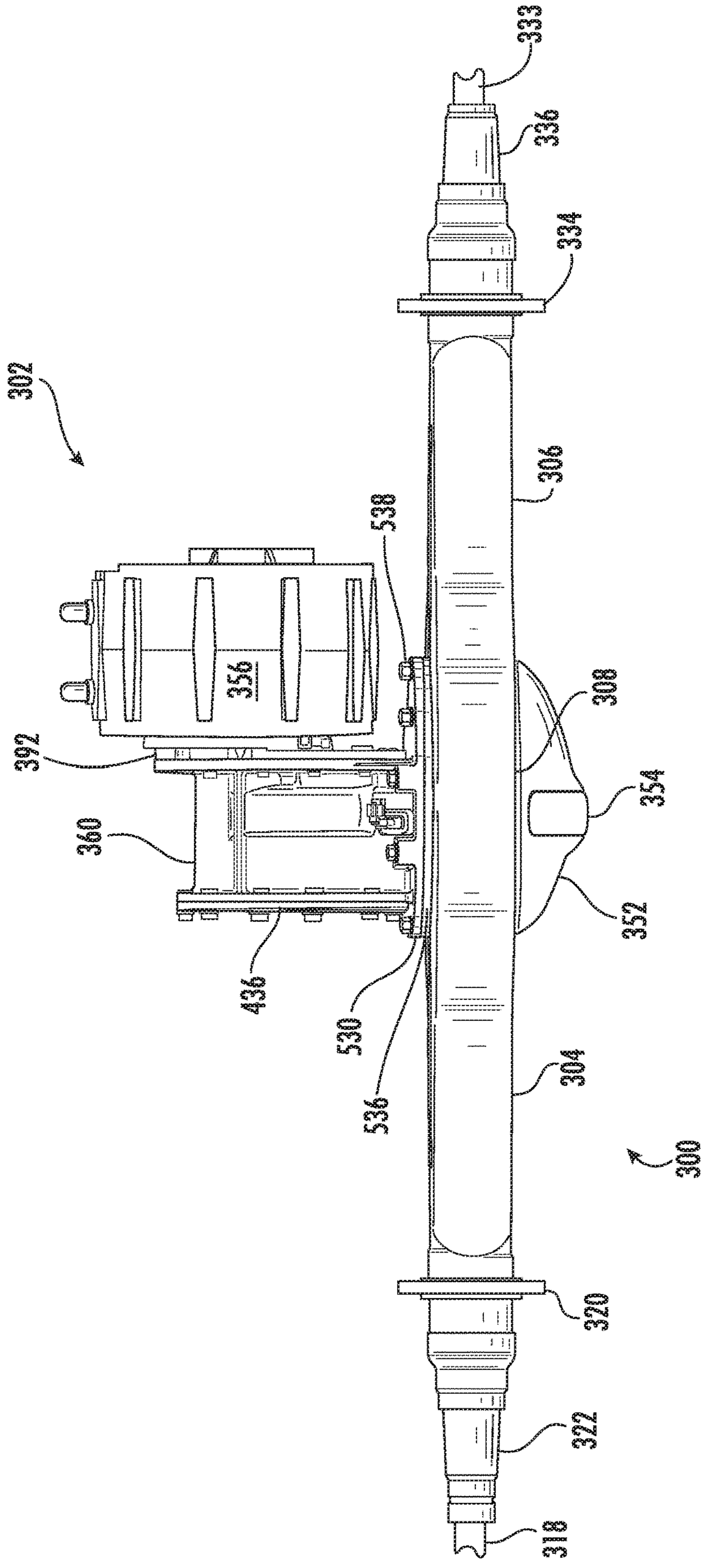
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FIG. 6

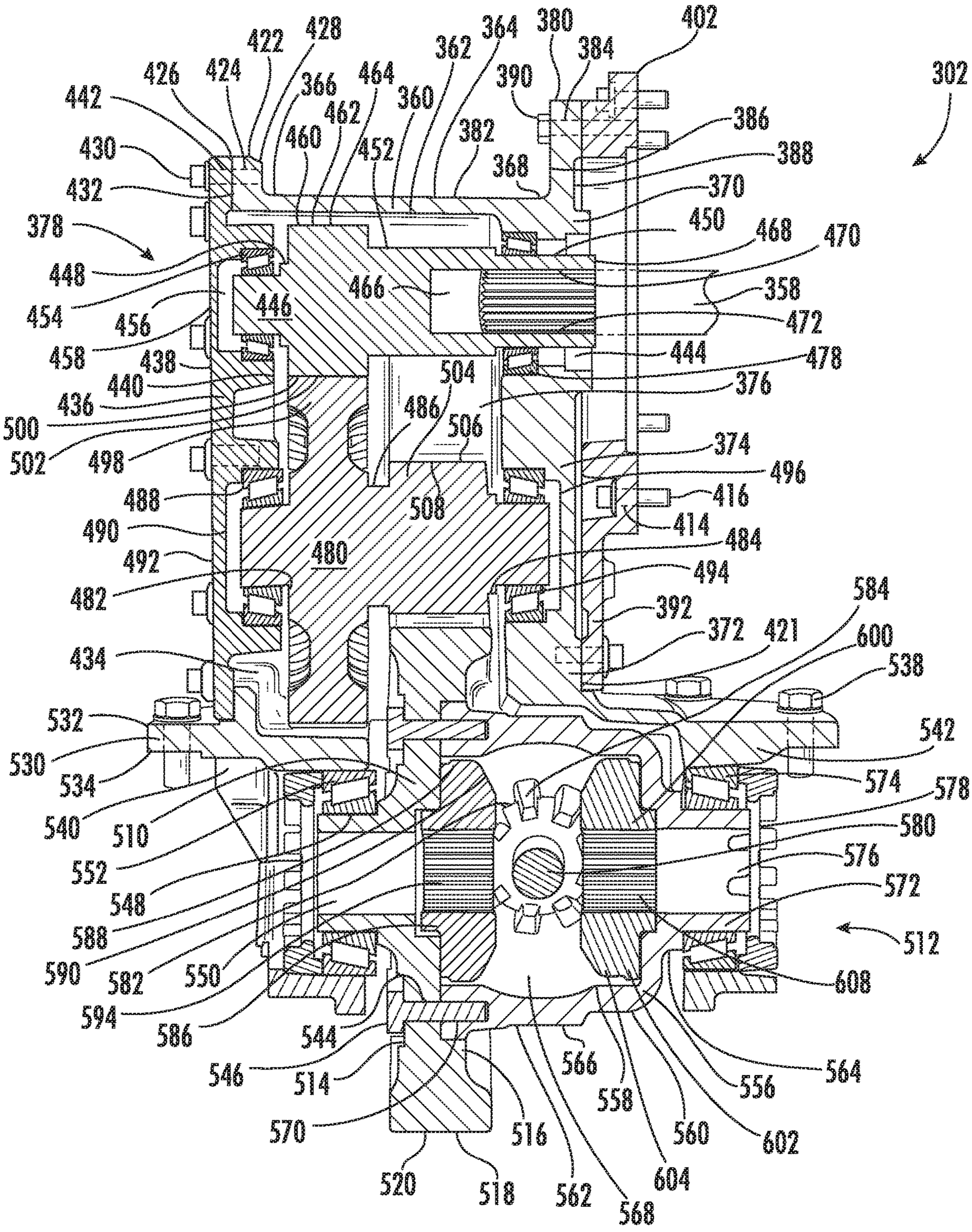
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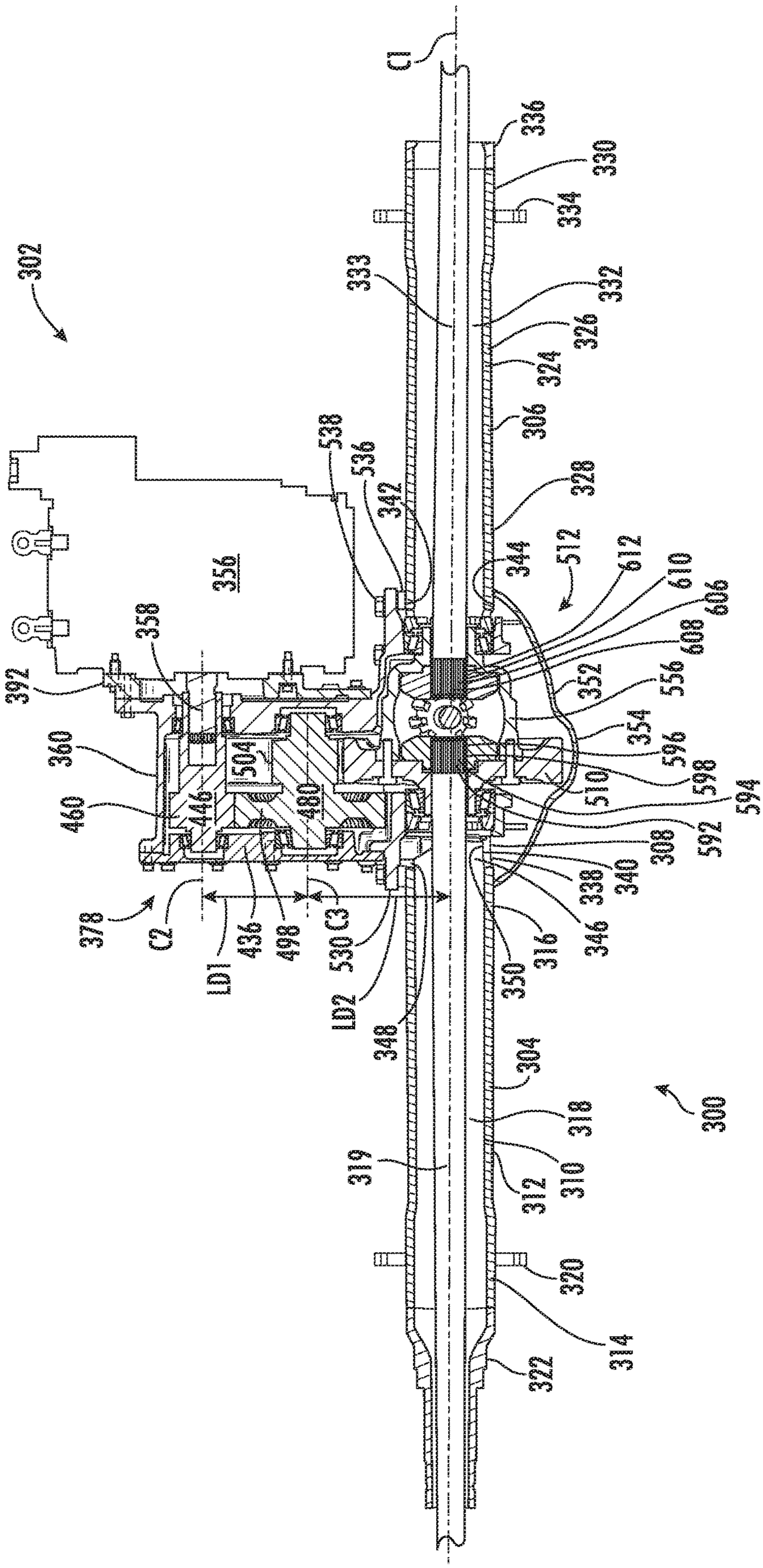
FIG. 6A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504
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446
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308
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338
346
316
350
378
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C3
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FIG. 6B

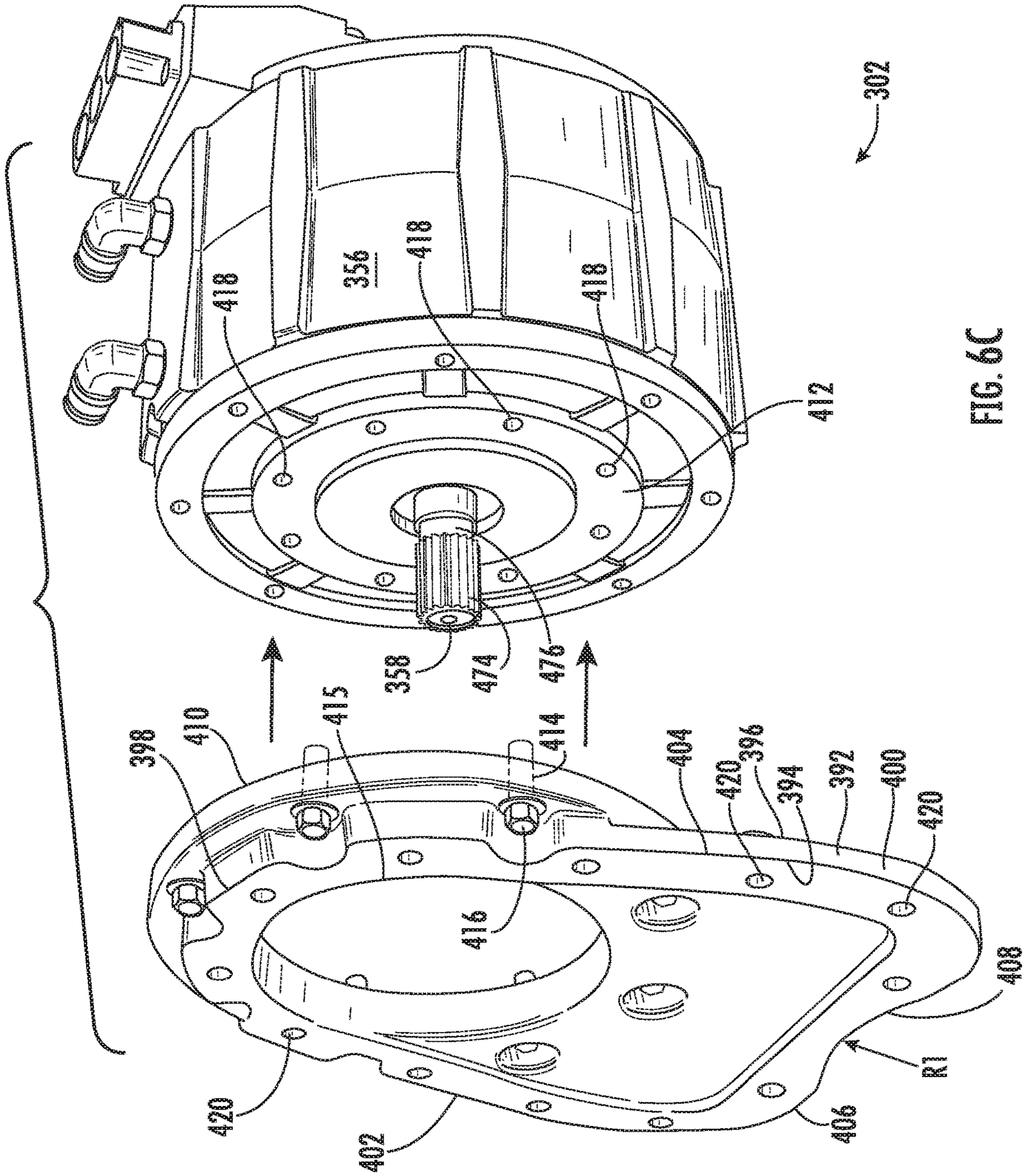
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FIG. 6C

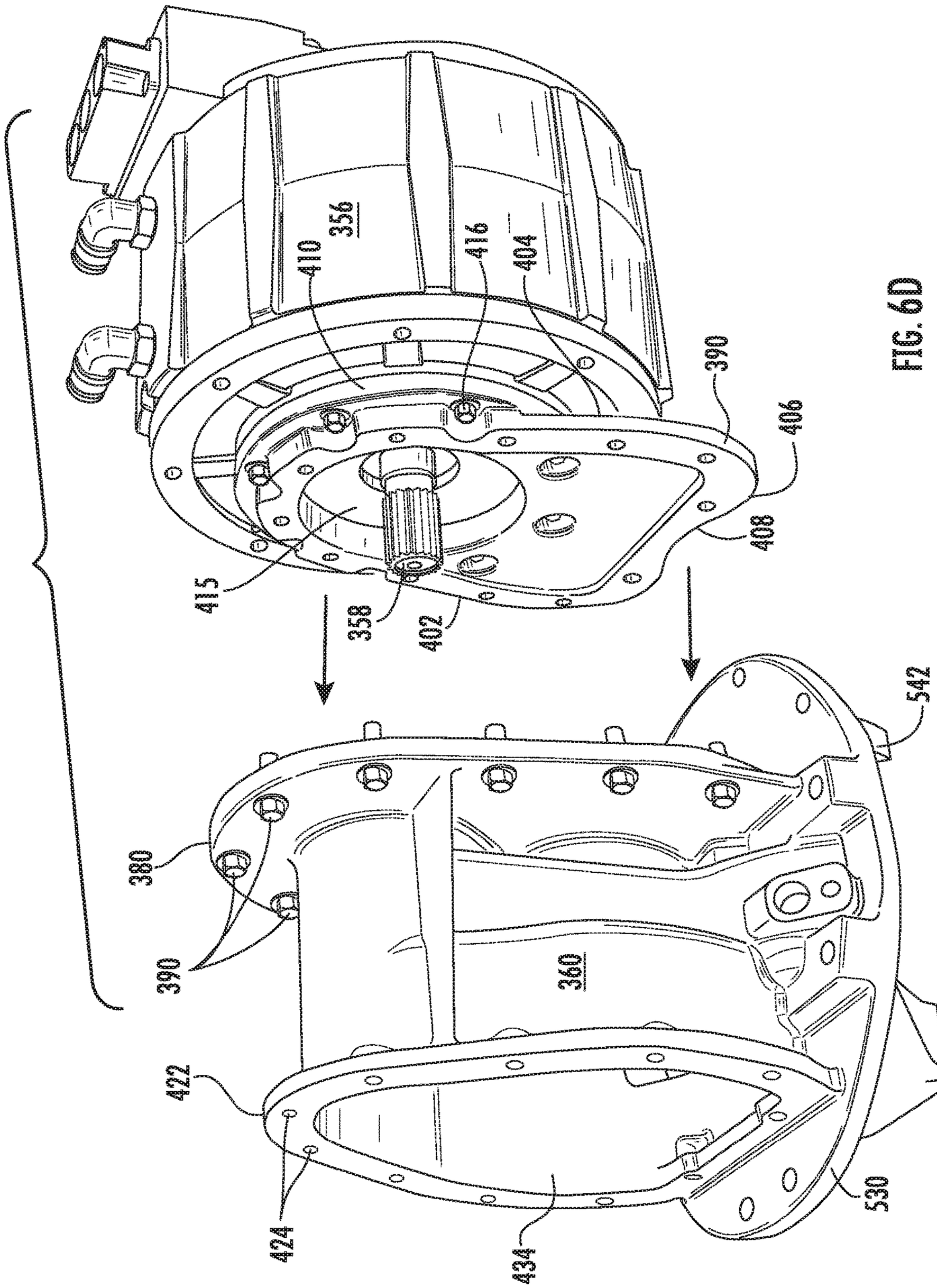
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FIG. 6D

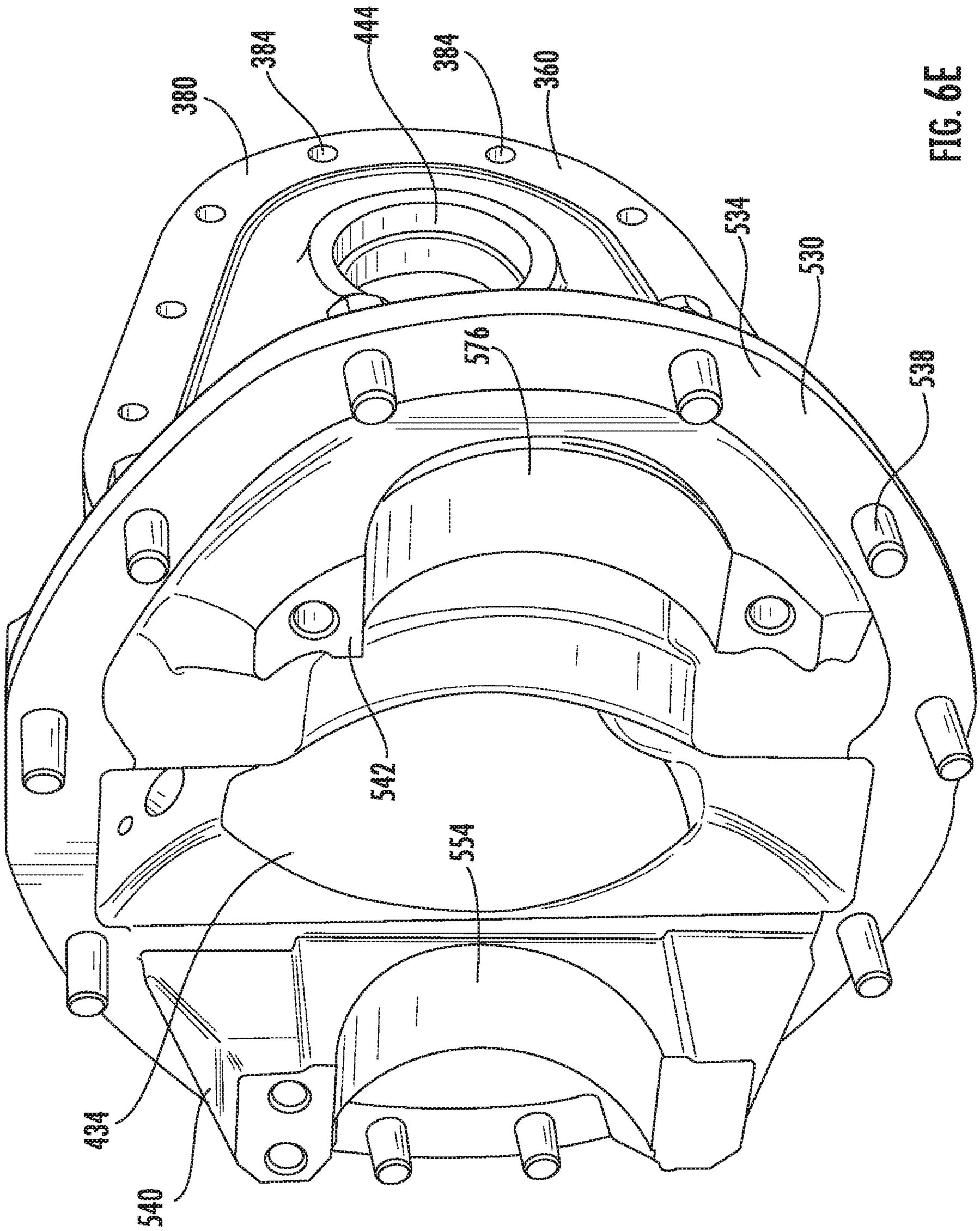

FIG. 6E

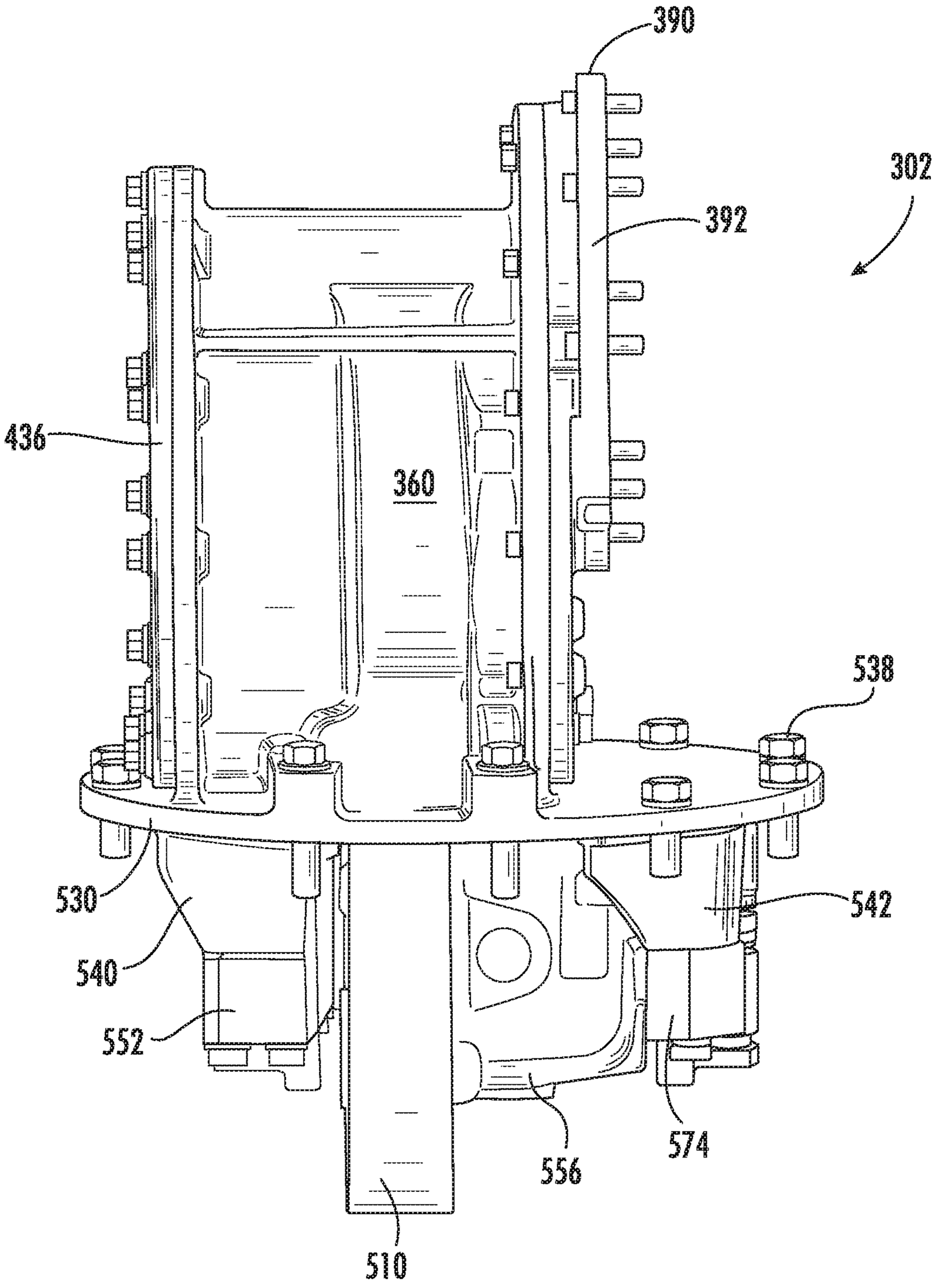

FIG. 6F

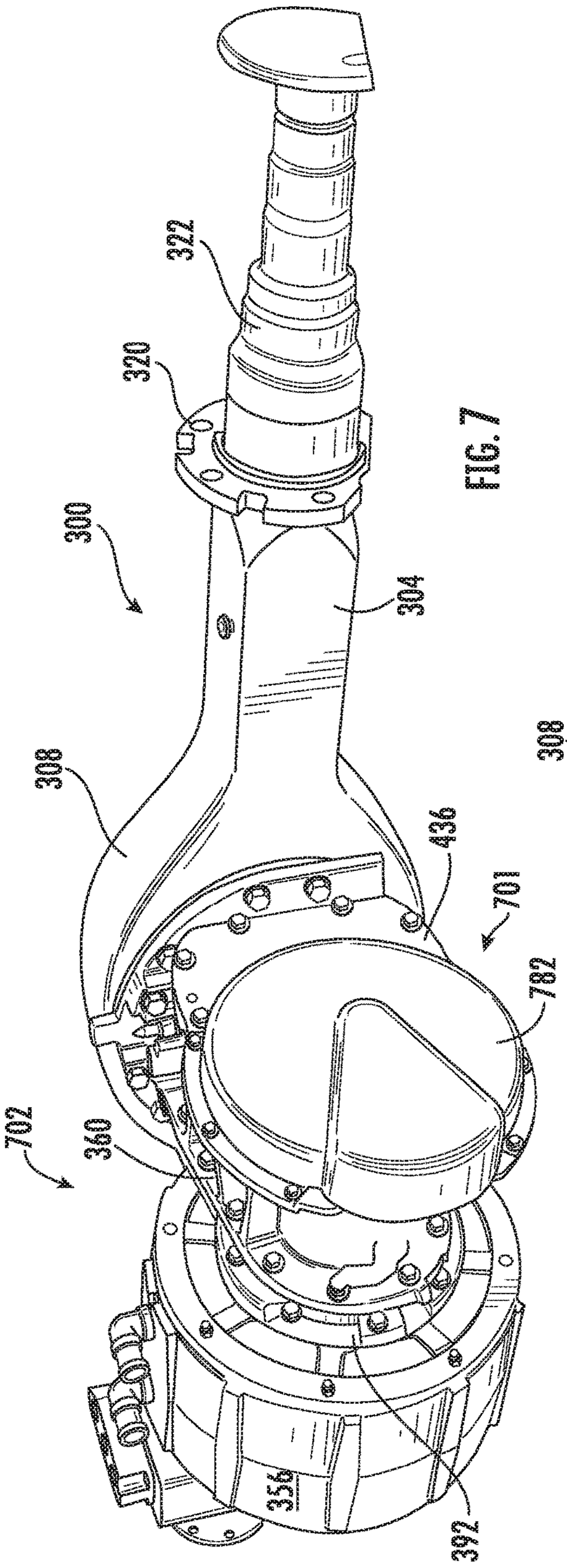
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FIG. 7

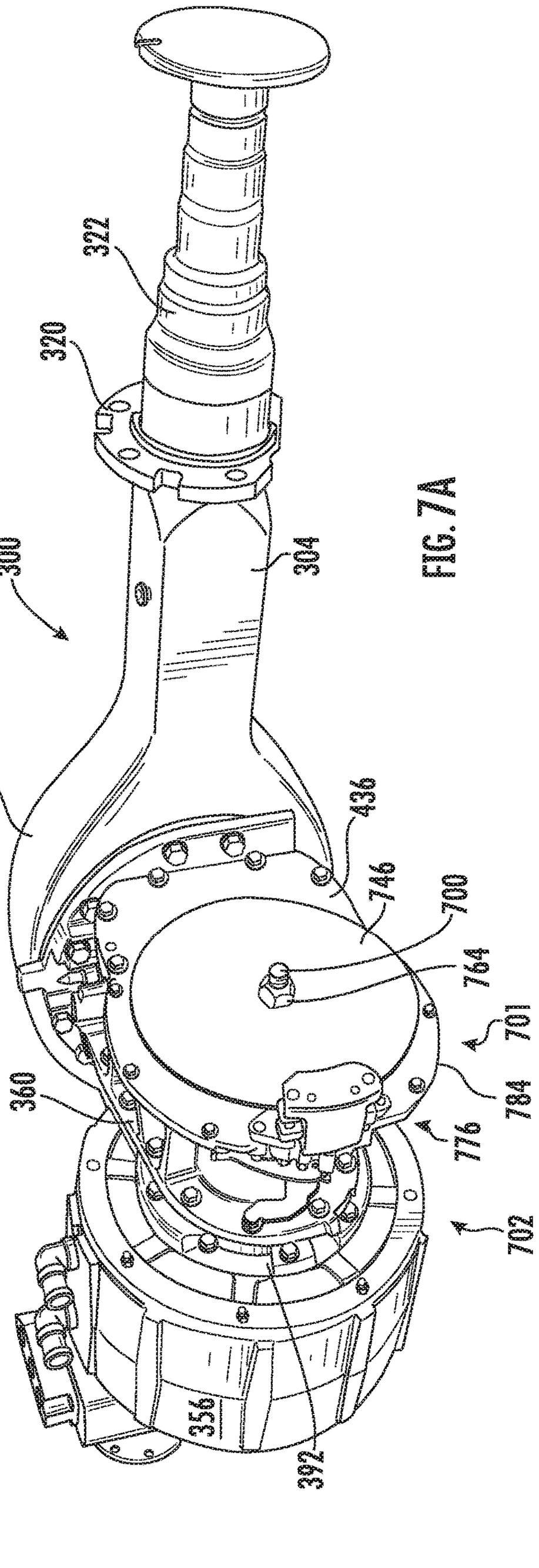
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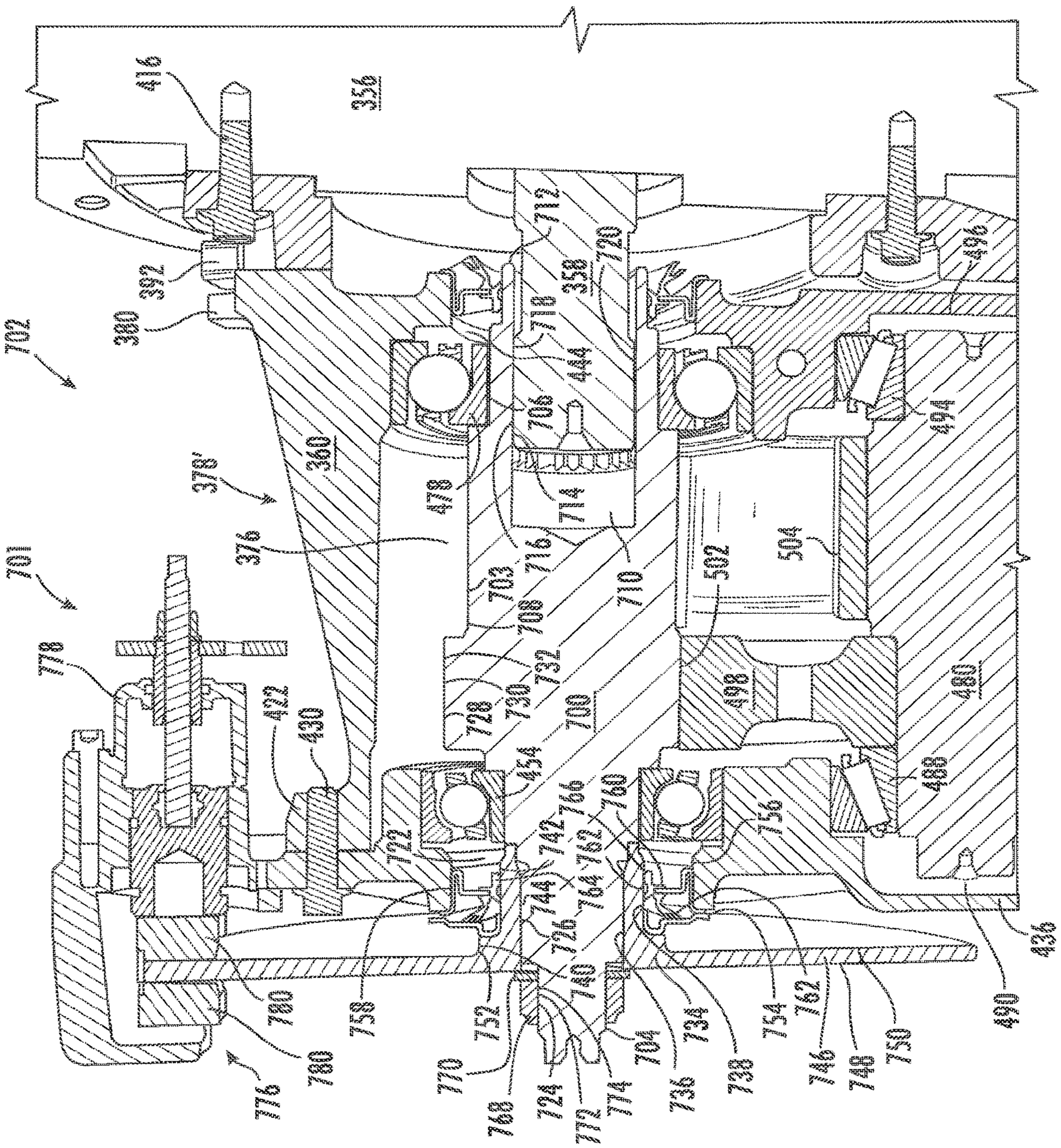
FIG. 7A

FIG. 7B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778
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742
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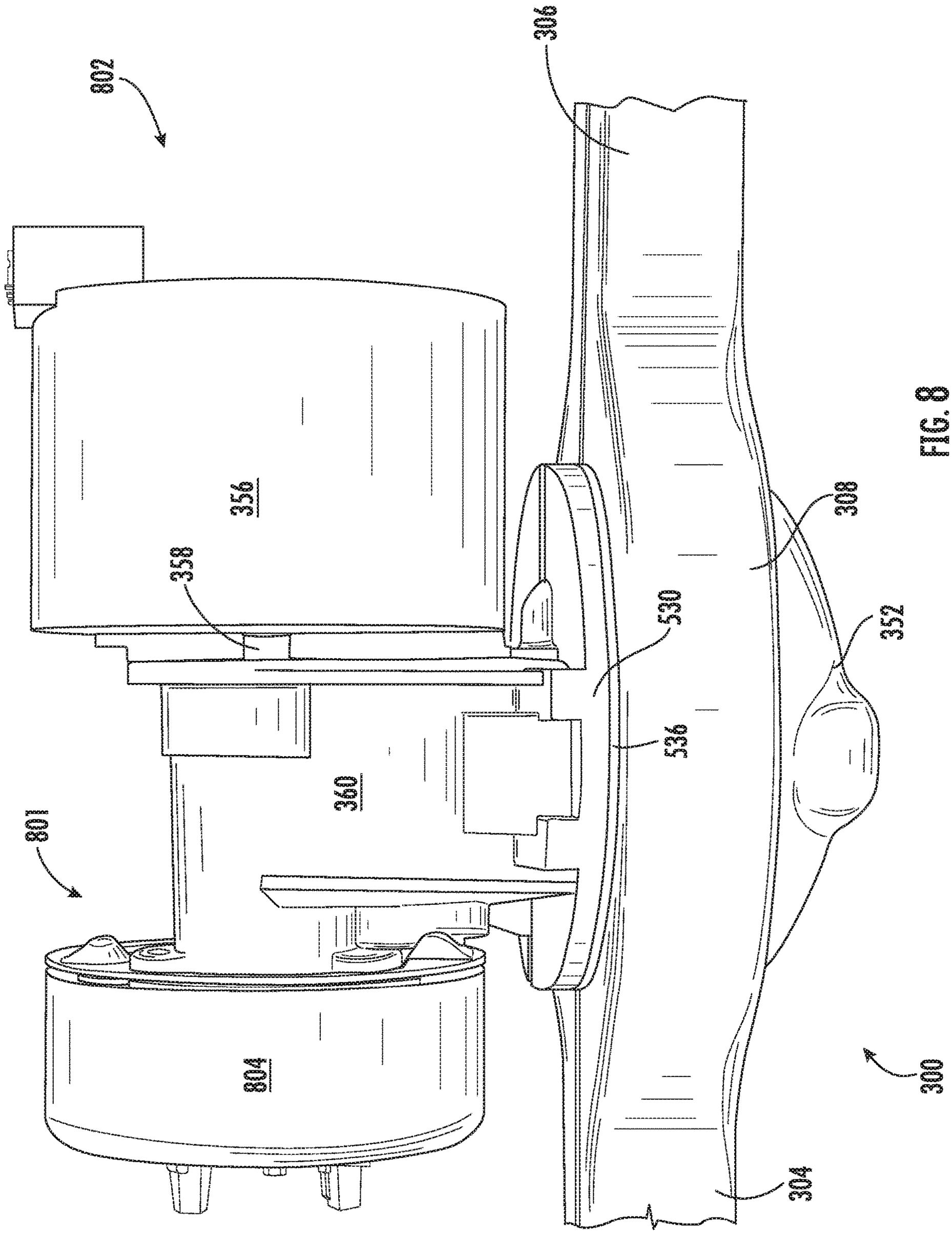
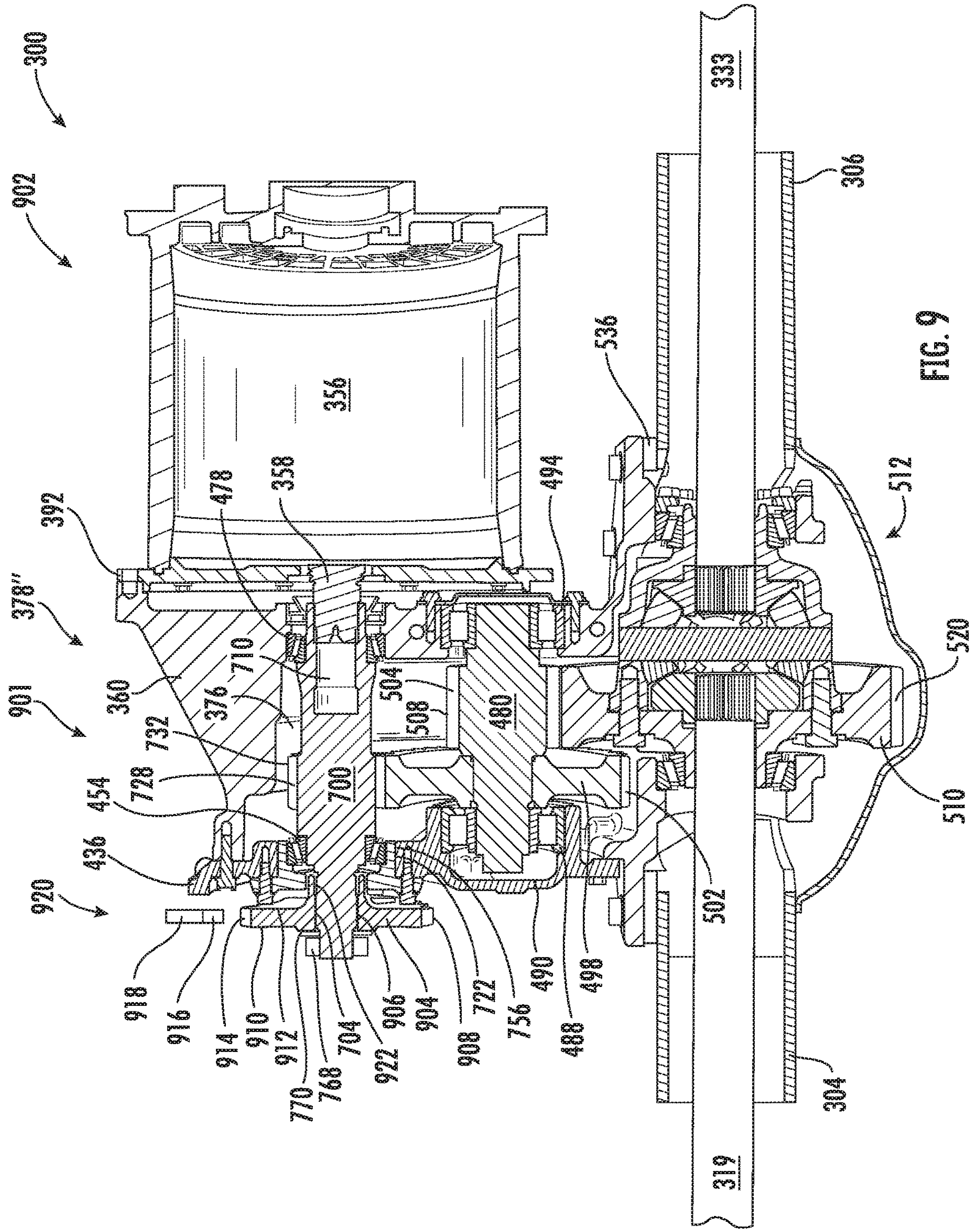


FIG. 8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704
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FIG. 9

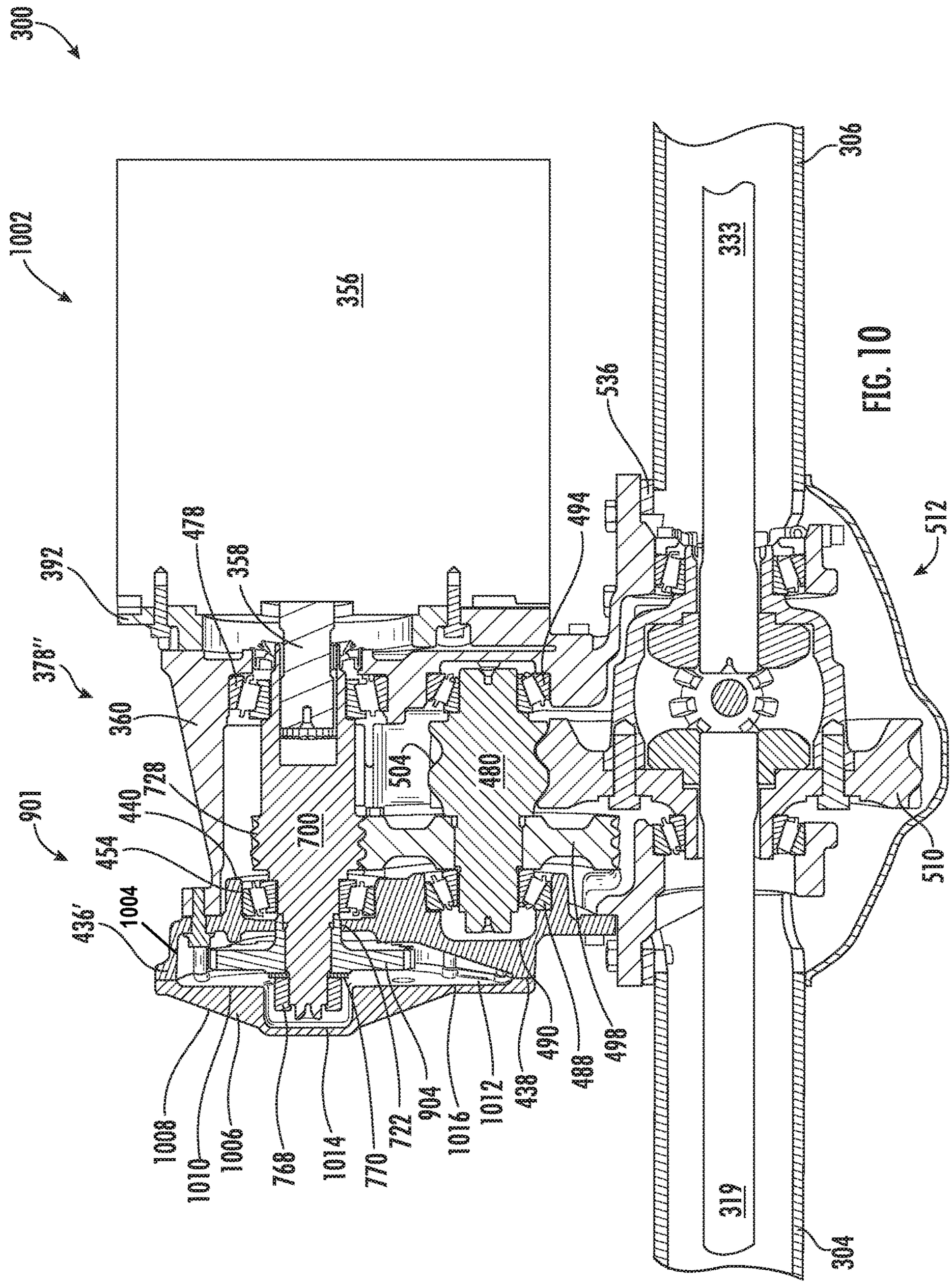
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FIG. 10

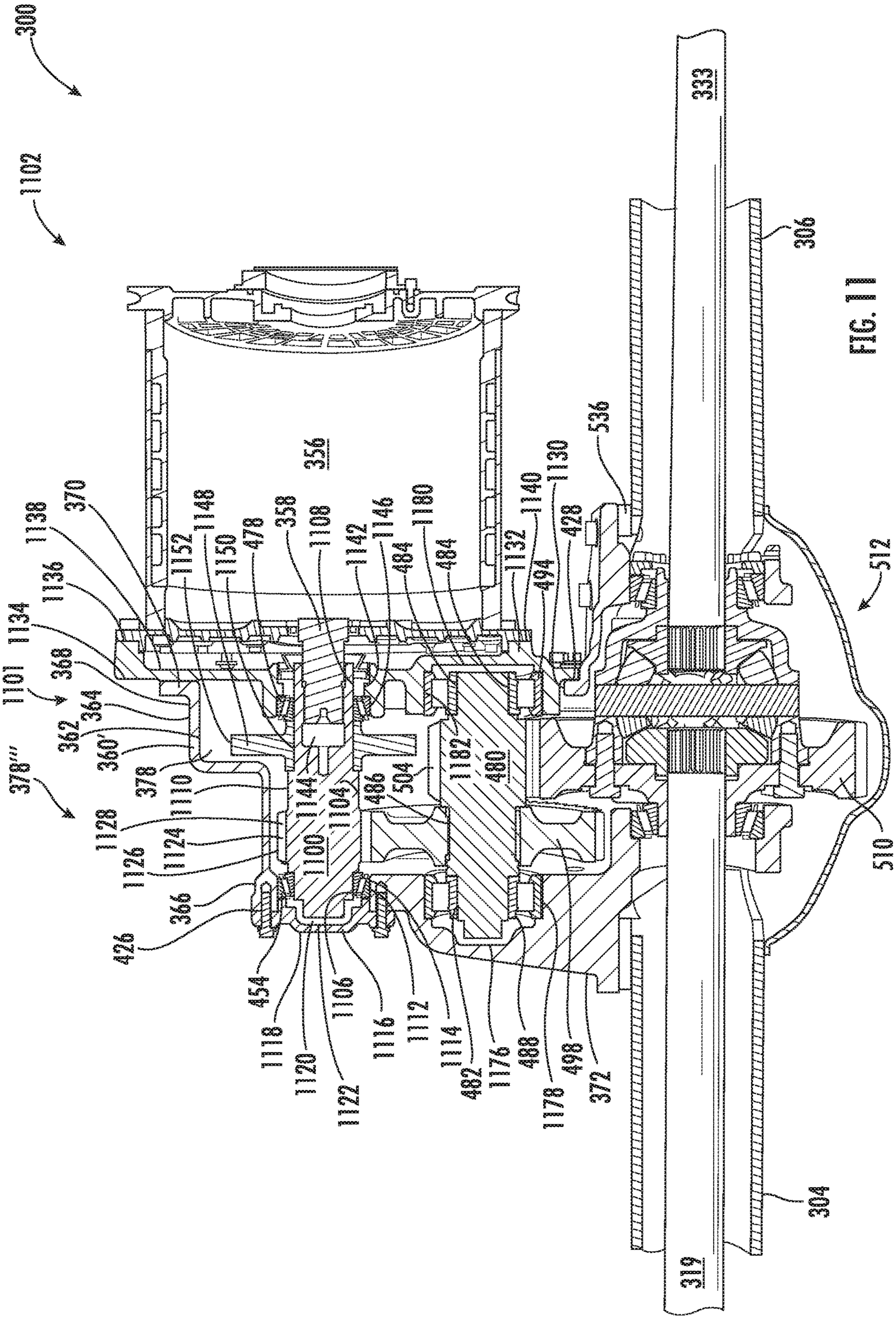
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FIG. 11

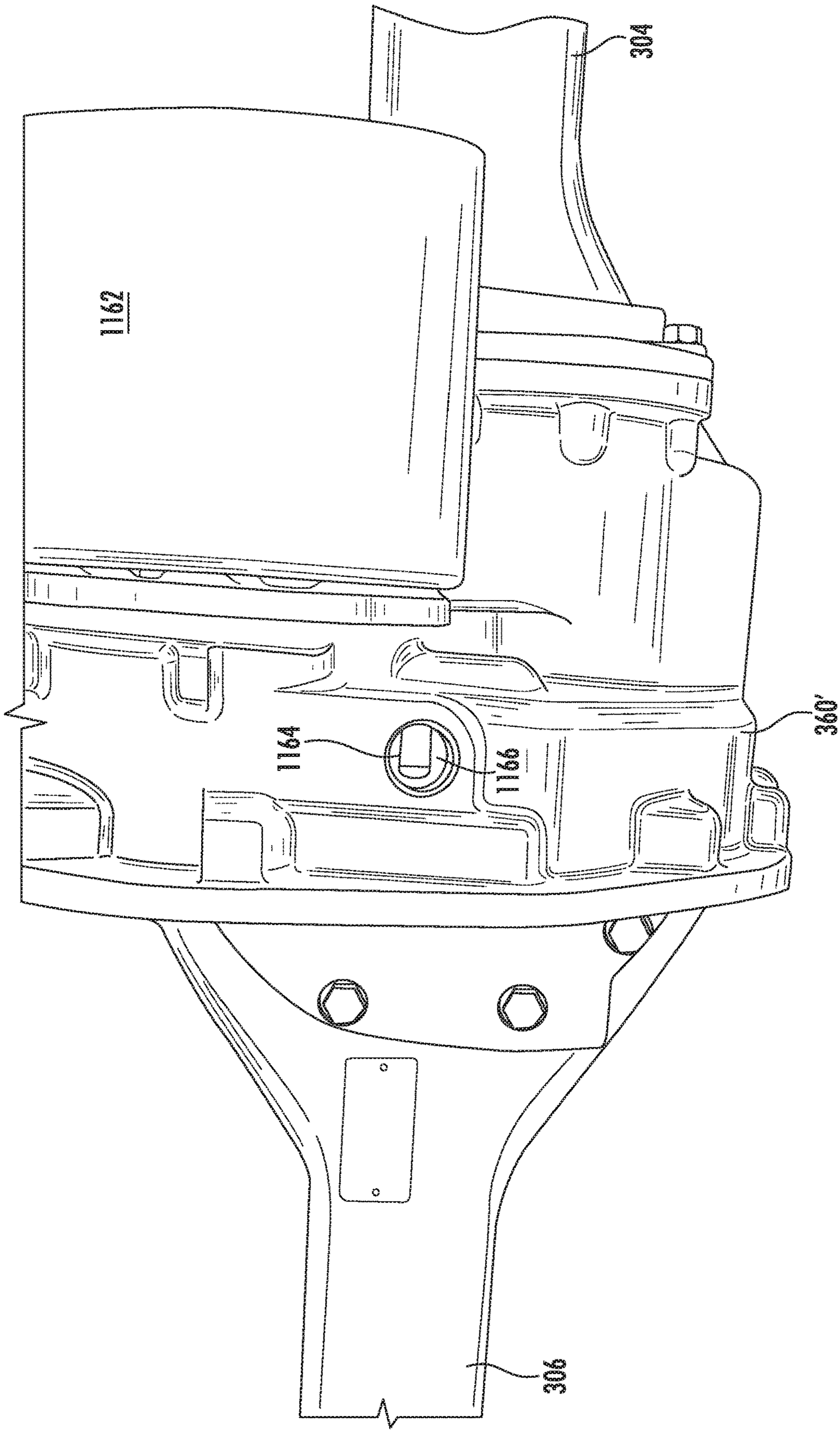

FIG. 11A

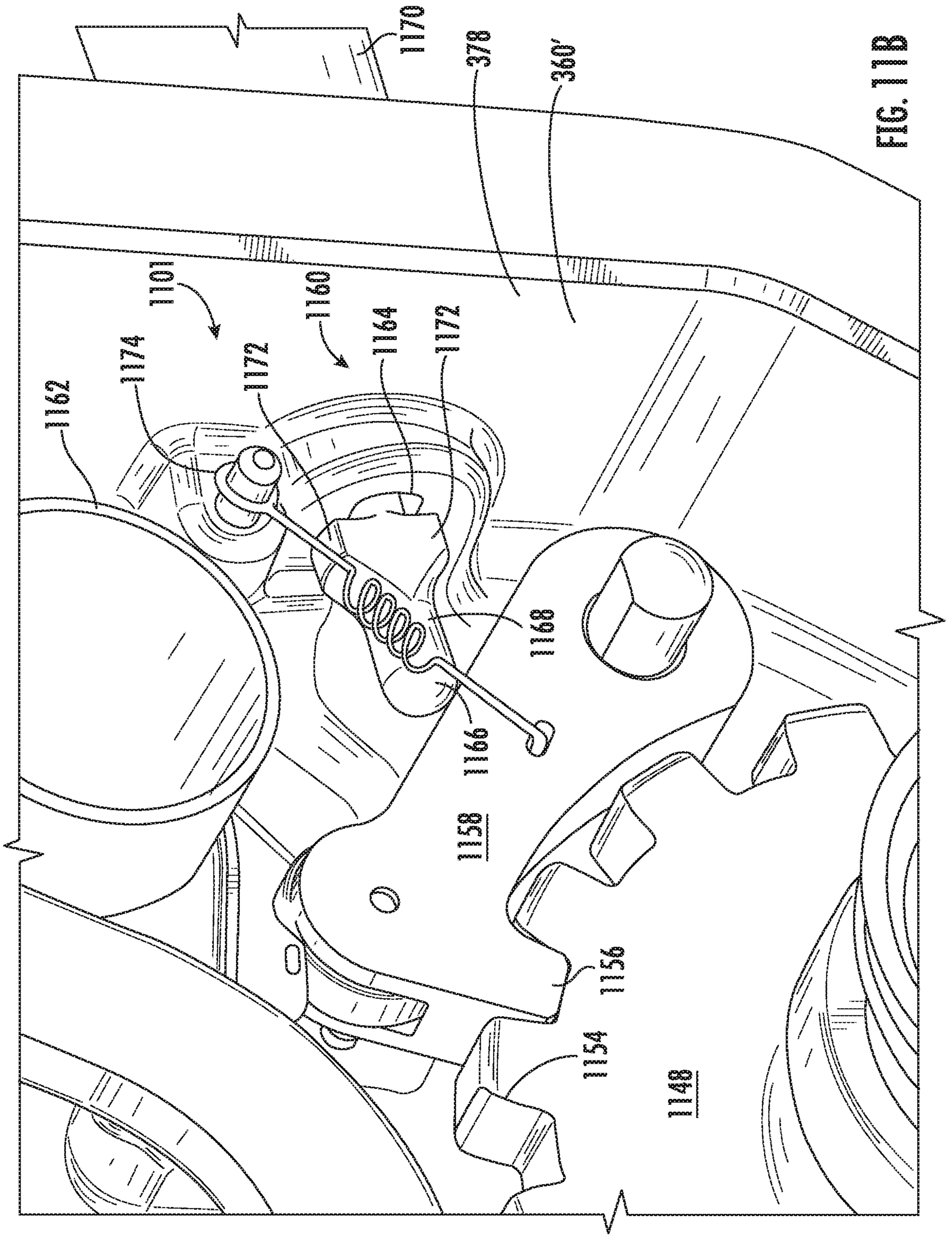
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Fig. 11B

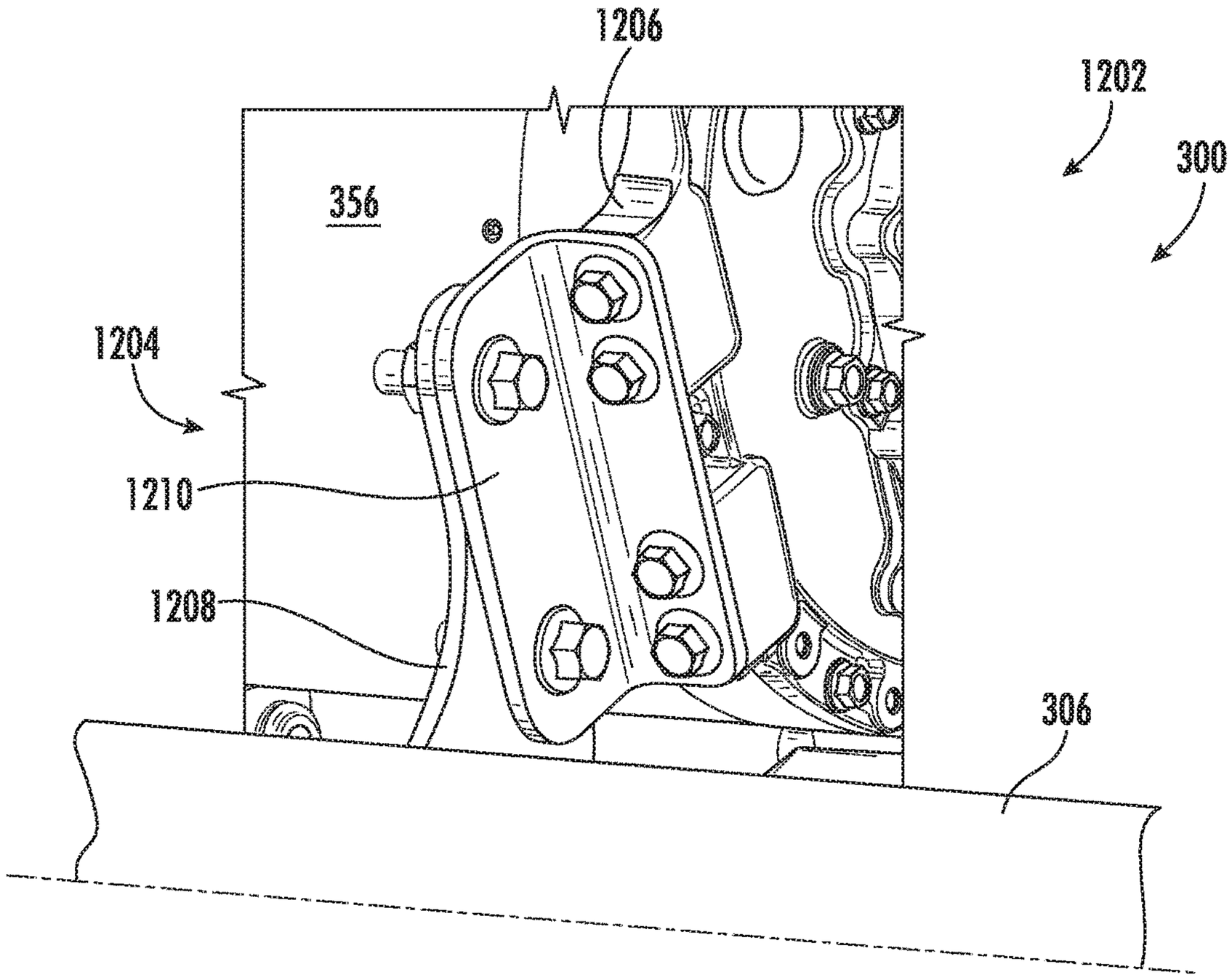
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FIG. 12

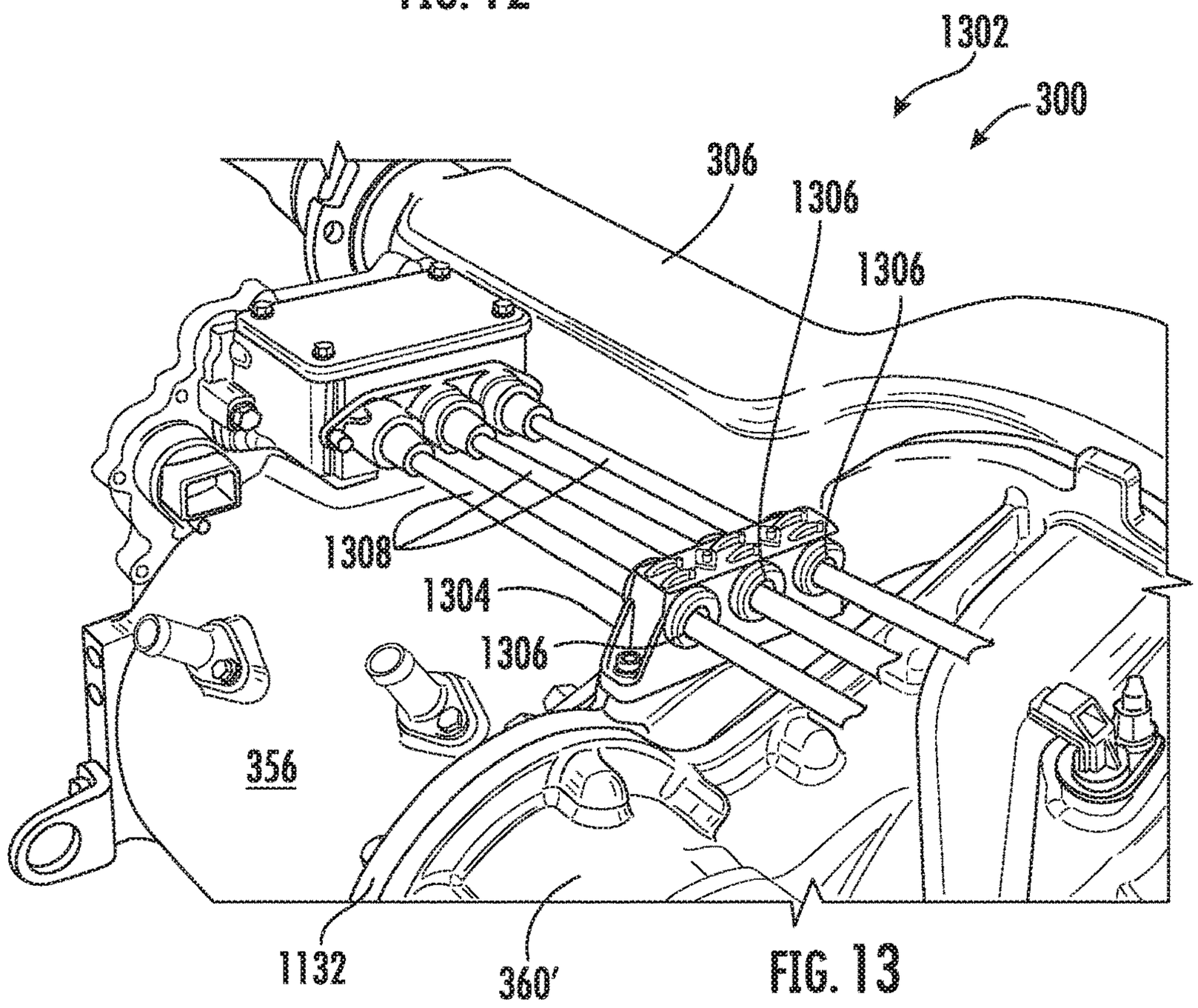
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FIG. 13

MODULAR HEAD ASSEMBLY FOR AN ELECTRIC AXLE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit to U.S. Provisional Patent Application No. 62/511,040 filed on May 25, 2017, which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to a modular electric axle head assembly for use in an electric vehicle and/or a hybrid electric vehicle.

BACKGROUND OF THE DISCLOSURE

In recent years' considerable attention has been given to producing vehicles with increased fuel efficiency to reduce the overall fuel consumption of motorized vehicles all over the world. Additionally, in light of increasingly stringent emission controls considerable attention has been given to producing vehicles that produce fewer emissions. As a result, considerable attention is being given to producing hybrid vehicles and all electric vehicles that have a reduced fuel consumption and produce fewer emissions. Hybrid vehicles typically use two or more distinct power sources to provide the power necessary to drive the vehicle.

Many conventional hybrid vehicles incorporate the use of an internal combustion engine and an electric motor to provide the rotational power necessary to drive the vehicle. The electric motor of the hybrid vehicle alone or in combination with the internal combustion engine provides the rotational power necessary to drive a front or rear axle system of the vehicle. Additionally, the internal combustion engine of some hybrid vehicles is used to provide the rotational power necessary to drive the front axle system, the rear axle system or a tandem axle system of the vehicle. These vehicles require the use of specialized drive-line and axle system components that are expensive to manufacture and maintain. It would therefore be advantageous to develop a modular electric axle head assembly that can be attached to and used in combination with a conventional axle assembly.

SUMMARY OF THE DISCLOSURE

A modular electric axle head assembly for a vehicle. An axle assembly of the vehicle includes a banjo portion with a first opening extending from an inner surface to an outer surface of an inboard side of the banjo portion. At least a portion of a differential assembly disposed within at the banjo portion of the axle assembly and is drivingly connected to at least a portion of a gear assembly. The gear assembly is also drivingly connected to a motor output shaft. At least a portion of the gear assembly is disposed within a hollow portion of a gear assembly housing. An outboard portion of the gear assembly housing has a mounting flange that is integrally connected to the inboard side of the banjo portion. A first and second protruding portion extends from the axle assembly mounting flange and provides rotational support for the differential assembly.

According to an aspect of the disclosure, the gear assembly of the modular electric axle head assembly may include a first gear shaft having a first gear and a second gear shaft having a second gear and a third gear. At least a portion of the second gear may be drivingly connected to the first gear and at least a portion of the third gear may be drivingly connected to at least a portion of a ring gear of the differential assembly.

According to an aspect of the disclosure, the first gear of the gear assembly has a plurality of first gear teeth, the second gear has a plurality of second gear teeth and the third gear has a plurality of third gear teeth. The plurality of first, second and third gear teeth may have a helix angle that reduces and/or eliminates an amount of axial force experienced by the second gear shaft of the gear assembly when in operation.

According to any of the previous aspect of the disclosure, the gear assembly may further include an opening that extends from the inner surface to the outer surface of the inboard portion of a first end of the gear assembly housing. At least a portion of the opening in the inboard portion of the first end of the gear assembly housing provides rotational support for at least a portion of a first end portion of the first gear shaft. At least a portion of one or more first bearing assemblies are interposed between an outer surface of the first end portion of the first gear shaft and a surface defining the opening in the inboard portion of the first end of the gear assembly housing.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a gear housing cover having a first side and a second side. The gear housing cover may have a size and shape to seal the opening in the inboard portion of the first end of the gear assembly housing. At least a portion of the gear housing cover may be integrally connected to at least a portion of the first end of the gear assembly housing.

According to any of the previous aspect of the disclosure, at least a portion of the second side of the gear housing cover may be in direct contact with at least a portion of the one or more first bearing assemblies.

According to any of the previous aspect of the disclosure, the gear housing cover may further include a receiving portion in the second side of the gear housing cover and the reviving portion in the second side of the gear housing cover may be of a size and shape to receive and/or retain at least a portion of the first end portion of the first gear shaft.

According to any of the previous aspect of the disclosure, the gear assembly housing may further include a receiving portion in the inner surface of the outboard portion of a first end portion of the gear assembly housing. At least a portion of one or more third bearing assemblies may be interposed between an outer surface of a first end portion of the second gear shaft and a surface defining the receiving portion in the inner surface of the outboard portion of the first end portion of the gear assembly housing.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a motor mounting member having a first side, a second side, an inboard portion and an outboard portion. At least a portion of the first side of the motor mounting member may be integrally connected to at least a portion of a second end of the gear assembly housing. The motor mounting member may further include a motor mounting portion on the second side of the motor mounting member. At least a portion of a motor may be integrally connected to at least a portion of the motor mounting portion of the motor mounting member. A motor output shaft extending through a motor mounting member opening extending from the first side to the second side of the motor mounting member.

According to any of the previous aspect of the disclosure, the motor mounting member opening may be of a size and shape needed to provide rotational support for at least a portion of a second end portion of the first gear shaft and the motor output shaft. At least a portion of one or more second bearing assemblies may be interposed between an outer surface of the second end portion of the first gear shaft and a surface defining the motor mounting member opening.

According to any of the previous aspect of the disclosure, the motor mounting member may further include a receiving portion in the first side of the outboard portion of the motor mounting member. At least a portion of one or more fourth bearing assemblies may be interposed between an outer surface of the second end portion of the second gear shaft and a surface defining the receiving portion of the motor mounting member.

According to any of the previous aspect of the disclosure, the one or more third bearing assemblies may be one or more cylindrical roller bearing assemblies and the one or more fourth bearing assemblies may be one or more cylindrical roller bearing assemblies.

According to any of the previous aspect of the disclosure, modular electric axle head assembly may further include a brake assembly.

According to any of the previous aspect of the disclosure, the brake assembly may include a parking gear and a parking pawl that is selectively engagable with the parking gear. At least a portion of the parking gear may be integrally connected to at least a portion of the first gear shaft and the parking pawl may be driven into engagement with the parking gear by using an actuation mechanism.

According to any of the previous aspect of the disclosure, the gear assembly housing may further include a brake assembly aperture extending from the inner surface to the outer surface of the gear assembly housing. The brake assembly aperture may be of a size and shape to receive and retain at least a portion of an assembly tool. When the assembly tool is retained within the gear assembly housing, at least a portion of a first end portion of the assembly tool drives the parking pawl into engagement with the parking gear thereby providing the space needed to assemble the actuation mechanism into the gear assembly of the modular electric axle head assembly.

According to any of the previous aspect of the disclosure, the brake assembly of the modular electric axle head assembly may include a rotor portion and a caliper assembly that is selectively engagable with the rotor portion of the brake assembly. At least a portion of the rotor portion of the brake assembly may be integrally connected to at least a portion of the first gear shaft of the gear assembly.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a braking assembly cover having a size and shape needed to encase at least a portion of the rotor portion and the caliper assembly of the brake assembly.

According to any of the previous aspect of the disclosure, the brake assembly may be a drum brake assembly that is integrally connected to at least a portion of the first gear shaft.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a strain relief member that is integrally connected to at least a portion of the motor mounting member. The strain relief member may have one or more retention apertures having a size and shape needed to receive and/or retain at least a portion of one or more terminals or data links used in the operation and/or control of the motor.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a motor stabilizing assembly that is integrally connected to at least a portion of the motor and an axle half shaft housing of the axle assembly.

According to any of the previous aspect of the disclosure, the modular electric axle head assembly may further include a gear housing cover having a first side, a second side, an inboard portion and an outboard portion. At least a portion of the gear housing cover may be integrally connected to at least a portion of a first end of the gear assembly housing. The inboard portion of the second side of the gear housing cover may have a first receiving portion and the outboard portion of the second side of the gear housing cover may have a second receiving portion. At least a portion of the first end portion of the first gear shaft may be received within at least a portion of one or more first bearing assemblies disposed within the first receiving portion of the gear housing cover. Additionally, at least a portion of a first end portion of the second gear shaft may be received within one or more third bearing assemblies disposed within at least a portion of the second receiving portion of the gear housing cover.

According to any of the previous aspect of the disclosure, the gear assembly housing may further include a receiving portion in the inner surface of the outboard portion of s the aid second end portion of the gear assembly housing. At least a portion of a second end portion of the second gear shaft may be received within one or more fourth bearing assemblies disposed within at least a portion of the receiving portion in the inner surface of the outboard portion of the second end portion of the gear assembly housing.

According to any of the previous aspect of the disclosure, the one or more third bearing assemblies may be one or more cylindrical roller bearing assemblies and the one or more fourth bearing assemblies may be one or more cylindrical roller bearing assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as other advantages of the present disclosure, will become readily apparent to those skilled in the art from the following detailed description when considered in light of the accompanying drawings in which:

FIG. **1** is a schematic top-plan view of a vehicle having one or more modular electric axle head assemblies according to an embodiment of the disclosure;

FIG. **2** is a schematic top-plan view of the vehicle illustrated in FIG. **1** according to an alternative embodiment of the disclosure where the vehicle has one or more modular electric axle head assemblies according to an embodiment of the disclosure;

FIG. **3** is a schematic top-plan view of the vehicle illustrated in FIGS. **1** and **2** according to still another embodiment of the disclosure where the vehicle has one or more modular electric axle head assemblies according to an embodiment of the disclosure;

FIG. **4** is a schematic top-plan view of another vehicle having one or more modular electric axle head assemblies according to an embodiment of the disclosure;

FIG. **5** is a schematic top-plan view of the vehicle illustrated in FIG. **4** having one or more modular electric axle head assemblies according to an embodiment of the disclosure;

FIG. **6** is a schematic top-plan view of a modular electric axle head assembly according to an embodiment of the disclosure;

FIG. **6**A is a cut-away schematic top-plan view of the modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIG. **6**;

FIG. **6**B is a cut-away schematic top-plan view of the electric axle with the modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIGS. **6** and **6**A;

FIG. **6**C is a schematic exploded perspective view of a portion of a modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIGS. **6**-**6**B;

FIG. **6**D is a schematic exploded perspective view of a portion of the modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIGS. **6**-**6**C;

FIG. **6**E is a schematic perspective view of a portion of the modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIGS. **6**-**6**D;

FIG. **6**F is a schematic top-plan view of the modular electric axle head assembly according to the embodiment of the disclosure illustrated in FIGS. **6**-**6**E;

FIG. **7** is a is a schematic perspective view of an electric axle with the modular electric axle head assembly according to an alternative embodiment of the disclosure;

FIG. **7**A is a schematic perspective view of a portion of the electric axle with the modular electric axle head assembly according to the embodiment illustrated in FIG. **7**;

FIG. **7**B is a schematic cut-away schematic top-plan view of the modular electric axle head assembly according to the embodiment illustrated in FIGS. **7** and **7**A;

FIG. **8** is a schematic top-plan view of a modular electric axle head assembly according to another embodiment of the disclosure;

FIG. **9** is a schematic top-plan view of a modular electric axle head assembly according to yet another embodiment of the disclosure;

FIG. **10** is a schematic top-plan view of a modular electric axle head assembly according to still yet another embodiment of the disclosure;

FIG. **11** is a schematic top-plan view of a modular electric axle head assembly according to still even yet a further embodiment of the disclosure;

FIG. **11**A is a schematic perspective view of a portion of the modular electric axle head assembly illustrated in FIG. **11** of the disclosure;

FIG. **11**B is a schematic perspective view of a portion so the modular electric axle head assembly illustrated in FIGS. **11** and **11**A of the disclosure;

FIG. **12** is a schematic perspective view of a portion of the modular electric axle head assembly illustrated in FIGS. **6**-**11**B having a motor stabilizing assembly according to an embodiment of the disclosure; and

FIG. **13** is a schematic perspective view of a portion of the modular electric axle head assembly illustrated in FIGS. **6**-**12** having a strain relief member according to an embodiment of the disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

It is to be understood that the invention may assume various alternative orientations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions, directions or other physical characteristics relating to the embodiments disclosed are not to be considered as limiting, unless the claims expressly state otherwise.

It is within the scope of this disclosure, and as a non-limiting example, that the modular electric axle head assembly disclosed herein may be used in automotive, off-road vehicle, all-terrain vehicle, construction, structural, marine, aerospace, locomotive, military, machinery, robotic and/or consumer product applications. Additionally, as a non-limiting example, the modular electric axle head assembly disclosed herein may also be used in passenger vehicle, electric vehicle, hybrid vehicle, commercial vehicle, autonomous vehicles, semi-autonomous vehicles and/or heavy vehicle applications.

Additionally, it is within the scope of this disclosure that the modular electric axle head assembly disclosed herein is for use with an axle assembly of a motor vehicle. As a non-limiting example, the modular electric axle head assembly disclosed herein may be used in connection with a rear axle system, a front axle system, a forward tandem axle system and/or a rear tandem axle system to drive one or more wheels of the vehicle.

FIG. **1** is a schematic top-plan view of a vehicle **2** having one or more modular electric axle head assemblies according to an embodiment of the disclosure. It is within the scope of this disclosure that the vehicle **2** may be a hybrid vehicle having an engine **4** that is used to provide the rotational power necessary to drive a front axle system **6** of the vehicle **2**. As non-limiting example, the engine **4** of the vehicle **2** can be an internal combustion engine, an external combustion engine, a heat engine, a gas turbine and/or a steam turbine. Drivingly connected to an end of the engine **4** is an engine output shaft **8**.

Drivingly connecting the engine **4** of the vehicle **2** to a transmission **10** is a transmission input shaft **12**. As illustrated in FIG. **1** of the disclosure, the transmission input shaft **12** is drivingly connected to an end of the engine output shaft **8** opposite the engine **4**. The transmission **10** is a power management system which provides controlled application of the rotational power generated by the engine **4** by means of a gear box.

A transmission output shaft **14** is drivingly connected to an end of the transmission **10** opposite the transmission input shaft **12**. The transmission output shaft **14** drivingly connects the transmission **10** to a differential **16** of the front axle system **6** via a front axle differential input shaft **18**. The front axle differential **16** is a set of gears that allows the outer drive wheel(s) of the vehicle **2** to rotate at a faster rate that the inner drive wheel(s). The rotational power is transmitted through the front axle system **6** as described in more detail below.

The front axle system **6** further includes a first front axle half shaft **20** and a second front axle half shaft **22**. The first front axle half shaft **20** extends substantially perpendicular to the front axle differential input shaft **18**. A first end portion **24** of the first front axle half shaft **20** is drivingly connected to a first front axle wheel assembly **26** and a second end portion **28** of the first front axle half shaft **20** is drivingly connected to an end of the front axle differential **16**. As a non-limiting example, the second end portion **28** of the first front axle half shaft **20** is drivingly connected to a differential side gear, a separate stub shaft, a separate coupling shaft, a first front axle differential output shaft, a first front axle half shaft disconnect system and/or a shaft that is formed as part of a differential side gear.

The second front axle half shaft **22** also extends substantially perpendicular to the front axle differential input shaft **18**. A first end portion **30** of the second front axle half shaft **22** is drivingly connected to a second front axle wheel assembly **32** and a second end portion **34** of the second front axle half shaft **22** is drivingly connected to an end of the front axle differential **16** opposite the first front axle input shaft **20**. As a non-limiting example, the second end portion **34** of the second front axle half shaft **22** is drivingly connected to a differential side gear, a separate stub shaft, a separate coupling shaft, a second front axle differential output shaft, a second front axle half shaft disconnect system and/or a shaft that is formed as part of a differential side gear.

The vehicle **2** further includes a rear tandem axle system **36** having a forward tandem axle system **38** and a rear tandem axle system **40**. As illustrated in FIG. **1** of the disclosure, the rear tandem axle system **36** includes a modular electric axle head assembly **42**. The modular electric axle head assembly **42** provides the rotational power needed to drive the forward tandem axle system **38** and/or the rear tandem axle system **40** of the vehicle **2**. The modular electric axle head assembly **42** includes an electric motor **44** that is drivingly connected to an electric motor output shaft **46**. Drivingly connected to an end of the electric motor output shaft **46** opposite the electric motor **44** is a gear assembly **48**. The gear assembly **48** is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor **44** of the modular electric axle head assembly **42**.

Drivingly connected to an end of the gear assembly **48** of the modular electric axle head assembly **42** opposite the electric motor **44** is an inter-axle differential **50** of a forward tandem axle differential **52** of the forward tandem axle system **38**. The inter-axle differential **50** is a device that divides the rotational power generated by the electric motor **44** between the forward tandem axle system **38** and the rear tandem axle system **40** of the vehicle **2**.

As illustrated in FIG. **1** of the disclosure, the inter-axle differential **50** is drivingly connected to the forward tandem axle differential **52** and a forward tandem axle system output shaft **54**. The forward tandem axle differential **52** is a set of gears that allows the outer drive wheel(s) of a vehicle **2** to rotate at a faster rate than the inner drive wheel(s).

The forward tandem axle system **38** further includes the use of a first forward tandem axle half shaft **54** and a second forward tandem axle half shaft **58**. A first end portion **60** of the first forward tandem axle half shaft **54** is drivingly connected to a first forward tandem axle wheel assembly **62** and a second end portion **64** of the first forward tandem axle half shaft **54** is drivingly connected to a side of the forward tandem axle differential **52**. As a non-limiting example, the second end portion **64** of the first forward tandem axle half shaft **54** is drivingly connected to a forward tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a first forward tandem axle differential output shaft, a first forward tandem axle half shaft disconnect system and/or a shaft that is formed as part of a forward tandem axle differential side gear.

As illustrated in FIG. **1** of the disclosure, a first end portion **66** of the second forward tandem axle half shaft **58** is drivingly connected to a second forward tandem axle wheel assembly **68**. A second end portion **70** of the second forward tandem axle half shaft **58** is drivingly connected to a side of the forward tandem axle differential **52** opposite the first forward tandem axle half shaft **54**. As a non-limiting example, the second end portion **70** of the second forward tandem axle half shaft **58** is drivingly connected to a forward tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a second forward tandem axle differential output shaft, a second forward tandem axle half shaft disconnect system and/or a shaft that is formed as part of a forward tandem axle differential side gear.

One end of the forward tandem axle system output shaft **54** is drivingly connected to a side of the inter-axle differential **50** opposite the modular electric axle head assembly **42**. Drivingly connected to an end of the forward tandem axle system output shaft **54** opposite the inter-axle differential **50** is a shaft **72**. The shaft **72** extends from the forward tandem axle system **38** toward the rear tandem axle system **40** of the vehicle **2**. As a non-limiting example, the shaft **72** is a drive shaft, a prop shaft, a Cardan shaft, a double cardan shaft, a universal joint shaft or a universal coupling shaft.

Drivingly connected to an end of the shaft **72** opposite the forward tandem axle system output shaft **54** is a rear tandem axle system input shaft **74**. An end of the rear tandem axle system input shaft **74** opposite the shaft **72** is drivingly connected to a rear tandem axle differential **76** of the rear tandem axle system **40** of the vehicle **2**. The rear tandem axle differential **76** is a set of gears that allows the outer drive wheel(s) of a vehicle **2** to rotate at a faster rate than the inner drive wheel(s). As it can be seen by referencing FIG. **1** of the disclosure, the rear tandem axle system input shaft **74** drivingly connects the inter-axle differential **50** to the rear tandem axle differential **76** of the rear tandem axle system **40** of the vehicle **2**. The rotational power is transmitted through the rear tandem axle system **40** as described in more detail below.

The rear tandem axle system **40** further includes the use of a first rear tandem axle half shaft **78** and a second rear tandem axle half shaft **80**. The first rear tandem axle half shaft **78** extends substantially perpendicular to the rear tandem axle system input shaft **74**. A first end portion **82** of the first rear tandem axle half shaft **78** is drivingly connected to a first rear tandem axle wheel assembly **84** and a second end portion **86** of the first rear tandem axle half shaft **78** is drivingly connected to a side of the rear tandem axle differential **76**. As a non-limiting example, the second end portion **86** of the first rear tandem axle half shaft **78** is drivingly connected to a rear tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a first rear tandem axle differential output shaft, a first rear tandem axle half shaft disconnect system and/or a shaft that is formed as part of a rear tandem axle differential side gear.

Extending substantially perpendicularly with the rear tandem axle system input shaft **74** is the second rear tandem axle half shaft **80**. A first end portion **88** of the second rear tandem axle half shaft **80** is drivingly connected to a second rear tandem axle wheel assembly **90**. As illustrated in FIG. **1** of the disclosure, a second end portion **92** of the second rear tandem axle half shaft **80** is drivingly connected to a side of the rear tandem axle differential **76** opposite the first rear tandem axle half shaft **78**. As a non-limiting example, the second end portion **92** of the second rear tandem axle half shaft **80** is drivingly connected to a rear tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a second rear tandem axle differential output shaft, a second rear tandem axle half shaft disconnect system and/or a shaft that is formed as part of a rear tandem axle differential side gear.

FIG. **2** is a schematic top-plan view of the vehicle **2** illustrated in FIG. **1** according to an alternative embodiment of the disclosure where the vehicle **2** has one or more modular electric axle head assemblies according to an embodiment of the disclosure. The vehicle **2** illustrated in

FIG. **2** of the disclosure is the same as the vehicle **2** illustrated in FIG. **1**, except where specifically noted below. As illustrated in FIG. **2** of the disclosure, the vehicle **2** does not include the engine **2** and the forward tandem axle differential **52** having the inter-axle differential **50** illustrated in FIG. **1**. In accordance with this embodiment of the disclosure, the vehicle **2** is an electric drive vehicle.

Drivingly connected to the front axle differential **16** of the front axle system **6** of the vehicle **2** is a front axle modular electric axle head assembly **100** according to an embodiment of the disclosure. The front axle modular electric axle head assembly **100** provides the rotational power necessary to drive the front axle system **6** of the vehicle **2**.

The front axle modular electric axle head assembly **100** includes an electric motor **102** that is drivingly connected to an electric motor output shaft **104**. Drivingly connected to an end of the electric motor output shaft **104** opposite the electric motor **102** is a gear assembly **106**. The gear assembly **106** is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor **102** of the front axle modular electric axle head assembly **100**. Drivingly connected to an end of the gear assembly **106** of the front axle modular electric axle head assembly **100** opposite the electric motor **102** is the front axle differential **16** of the front axle system **6**.

As illustrated in FIG. **2** of the disclosure, a forward tandem axle modular electric axle head assembly **108** provides the rotational power necessary to drive the forward tandem axle system **38** of the vehicle **2**. The forward tandem axle modular electric axle head assembly **108** includes an electric motor **110** that is drivingly connected to an electric motor output shaft **112**. Drivingly connected to an end of the electric motor output shaft **112** opposite the electric motor **110** is a gear assembly **114**. The gear assembly **114** is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor **110** of the forward tandem axle modular electric axle head assembly **108**.

Drivingly connected to an end of the gear assembly **114** opposite the electric motor **110** is a forward tandem axle differential **116** of the forward tandem axle system **38** of the vehicle **2**. The forward tandem axle differential **116** is a set of gears that allows the outer drive wheel(s) of a vehicle **2** to rotate at a faster rate than the inner drive wheel(s).

As illustrated in FIG. **2** of the disclosure, the second end portion **64** of the first forward tandem axle half shaft **56** is drivingly connected to a side of the forward tandem axle differential **116**. As a non-limiting example, the second end portion **64** of the first forward tandem axle half shaft **56** is drivingly connected to a forward tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a first forward tandem axle differential output shaft, a first forward tandem axle half shaft disconnect system and/or a shaft that is formed as part of a forward tandem axle differential side gear.

The second end portion **70** of the second forward tandem axle half shaft **58** is drivingly connected to a side of the forward tandem axle differential **116** opposite the first forward tandem axle half shaft **56**. As a non-limiting example, the second end portion **70** of the second forward tandem axle half shaft **58** is drivingly connected to a forward tandem axle differential side gear, a separate stub shaft, a separate coupling shaft, a second forward tandem axle differential output shaft, a second forward tandem axle half shaft disconnect system and/or a shaft that is formed as part of a forward tandem axle differential side gear.

A rear tandem axle modular electric axle head assembly **118** provides the rotational power necessary to drive the rear tandem axle system **40** of the vehicle **2**. The rear tandem axle modular electric axle head assembly **118** includes an electric motor **120** that is drivingly connected to an electric motor output shaft **122**. Drivingly connected to an end of the electric motor output shaft **122** opposite the electric motor **120** is a gear assembly **124**. The gear assembly **124** is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor **120** of the rear tandem axle modular electric axle head assembly **118**. Drivingly connected to an end of the gear assembly **124** opposite the electric motor **120** is the rear tandem axle differential **76** of the rear tandem axle system **40** of the vehicle **2**.

FIG. **3** is a schematic top-plan view of the vehicle **2** illustrated in FIGS. **1** and **2** according to still another embodiment of the disclosure where the vehicle **2** has one or more modular electric axle head assemblies according to an embodiment of the disclosure. The vehicle **2** illustrated in FIG. **3** of the disclosure is the same as the vehicle **2** illustrated in FIGS. **1** and **2**, except where specifically noted below. As illustrated in FIG. **3** of the disclosure, the vehicle **2** does not include the front axle modular electric axle head assembly **100** illustrated in FIG. **2**. In accordance with this embodiment of the disclosure, the vehicle **2** is a hybrid vehicle.

Drivingly connected to an end of the transmission output shaft **14** opposite the transmission **10** is a shaft **150**. As illustrated in FIG. **3** of the disclosure, the shaft **150** extends from the transmission **10** to the forward tandem axle system **38** of the vehicle **2**. As a non-limiting example, the shaft **72** is a drive shaft, a prop shaft, a Cardan shaft, a double cardan shaft, a universal joint shaft or a universal coupling shaft.

Drivingly connected to an end of the shaft **150** opposite the transmission **10** is a forward tandem axle system input shaft **152**. An end of the forward tandem axle system input shaft **152** opposite the shaft **150** is drivingly connected to the forward tandem axle differential **116** of the forward tandem axle system **38** of the vehicle **2**.

In accordance with this embodiment of the disclosure illustrated in FIG. **3**, the rear tandem axle system **40** of the vehicle **2** includes the rear tandem axle modular electric axle head assembly **118**. The rear tandem axle modular electric axle head assembly **118** provides the rotational power necessary to drive rear tandem axle system **40** of the vehicle **2**. According to this embodiment of the disclosure, the rear tandem axle modular electric axle head assembly **118** may be activated to selectively transition the vehicle **2** from a 6×2 driving mode to a 6×4 driving mode on the fly without having to stop the vehicle **2**.

FIG. **4** is a schematic top-plan view of another vehicle **200** having one or more modular electric axle head assemblies according to an embodiment of the disclosure. It is within the scope of this disclosure that the vehicle **200** may be a hybrid vehicle having an engine **202** that is used to provide the rotational power necessary to drive a front axle system **204** of the vehicle **200**. As non-limiting example, the engine **202** of the vehicle **200** can be an internal combustion engine, an external combustion engine, a heat engine, a gas turbine and/or a steam turbine. Drivingly connected to an end of the engine **202** is an engine output shaft **206**.

Drivingly connecting the engine **202** of the vehicle **200** to a transmission **208** is a transmission input shaft **210**. As illustrated in FIG. **4** of the disclosure, the transmission input shaft **210** is drivingly connected to an end of the engine output shaft **206** opposite the engine **202**. The transmission

208 is a power management system which provides controlled application of the rotational power generated by the engine 202 by means of a gear box.

A transmission output shaft 212 is drivingly connected to an end of the transmission 208 opposite the transmission input shaft 210. The transmission output shaft 212 drivingly connects the transmission 208 to a differential 214 of the front axle system 204 via a front axle differential input shaft 216. The front axle differential 214 is a set of gears that allows the outer drive wheel(s) of the vehicle 200 to rotate at a faster rate that the inner drive wheel(s). The rotational power is transmitted through the front axle system 204 as described in more detail below.

The front axle system 204 further includes a first front axle half shaft 216 and a second front axle half shaft 218. The first front axle half shaft 216 extends substantially perpendicular to the front axle differential input shaft 216. A first end portion 220 of the first front axle half shaft 216 is drivingly connected to a first front axle wheel assembly 222 and a second end portion 224 of the first front axle half shaft 216 is drivingly connected to an end of the front axle differential 214. As a non-limiting example, the second end portion 224 of the first front axle half shaft 216 is drivingly connected to a differential side gear, a separate stub shaft, a separate coupling shaft, a first front axle differential output shaft, a first front axle half shaft disconnect system and/or a shaft that is formed as part of a differential side gear.

Extending substantially perpendicular to the front axle differential input shaft 216 is the second front axle half shaft 218 of the front axle system 204 of the vehicle 200. A first end portion 226 of the second front axle half shaft 218 is drivingly connected to a second front axle wheel assembly 228 and a second end portion 230 of the second front axle half shaft 218 is drivingly connected to an end of the front axle differential 214 opposite the first front axle input shaft 216. As a non-limiting example, the second end portion 230 of the second front axle half shaft 218 is drivingly connected to a differential side gear, a separate stub shaft, a separate coupling shaft, a second front axle differential output shaft, a second front axle half shaft disconnect system and/or a shaft that is formed as part of a differential side gear.

As illustrated in FIG. 4 of the disclosure, a rear axle modular electric axle head assembly 232 provides the rotational power necessary to drive a rear axle system 234 of the vehicle 200. The rear axle modular electric axle head assembly 232 includes an electric motor 236 that is drivingly connected to an electric motor output shaft 238. Drivingly connected to an end of the electric motor output shaft 238 opposite the electric motor 236 is a gear assembly 240. The gear assembly 240 is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor 236 of the rear axle modular electric axle head assembly 232.

Drivingly connected to an end of the gear assembly 240 opposite the electric motor 236 is a rear axle differential 242 of the rear axle system 234 of the vehicle 200. The rear axle differential 242 is a set of gears that allows the outer drive wheel(s) of a vehicle 200 to rotate at a faster rate than the inner drive wheel(s). The rotational power is transmitted through the rear axle system 234 as described in more detail below.

The rear axle system 234 further includes the use of a first rear axle half shaft 244 and a second rear axle half shaft 246. A first end portion 248 of the first rear axle half shaft 244 is drivingly connected to a first rear axle wheel assembly 250 and a second end portion 252 of the first rear axle half shaft 244 is drivingly connected to a side of the rear axle differential 242. As a non-limiting example, the second end portion 252 of the first rear axle half shaft 244 is drivingly connected to a rear axle differential side gear, a separate stub shaft, a separate coupling shaft, a first rear axle differential output shaft, a first rear axle half shaft disconnect system and/or a shaft that is formed as part of a rear axle differential side gear.

A first end portion 254 of the second rear axle half shaft 246 is drivingly connected to a second rear axle wheel assembly 256. As illustrated in FIG. 1 of the disclosure, a second end portion 258 of the second rear axle half shaft 246 is drivingly connected to a side of the rear axle differential 242 opposite the first rear axle half shaft 246. As a non-limiting example, the second end portion 258 of the second rear axle half shaft 246 is drivingly connected to a rear axle differential side gear, a separate stub shaft, a separate coupling shaft, a second rear axle differential output shaft, a second rear axle half shaft disconnect system and/or a shaft that is formed as part of a rear axle differential side gear.

FIG. 5 is a schematic top-plan view of the vehicle 200 illustrated in FIG. 4 having one or more modular electric axle head assemblies according to an embodiment of the disclosure. The vehicle 200 illustrated in FIG. 5 of the disclosure is the same as the vehicle 200 illustrated in FIG. 4, except where specifically noted below. As illustrated in FIG. 5 of the disclosure, the vehicle 200 does not include the engine 202 illustrated in FIG. 4. In accordance with this embodiment of the disclosure, the vehicle 200 is an electric drive vehicle.

Drivingly connected to the front axle differential 214 of the front axle system 204 of the vehicle 200 is a front axle modular electric axle head assembly 260 according to an embodiment of the disclosure. The front axle modular electric axle head assembly 260 provides the rotational power necessary to drive the front axle system 204 of the vehicle 200.

The front axle modular electric axle head assembly 260 includes an electric motor 262 that is drivingly connected to an electric motor output shaft 264. Drivingly connected to an end of the electric motor output shaft 264 opposite the electric motor 262 is a gear assembly 266. The gear assembly 266 is a system of gears (not shown) that reduces the overall rotational speed and increases the torque generated by the electric motor 262 of the front axle modular electric axle head assembly 260. Drivingly connected to an end of the gear assembly 266 of the front axle modular electric axle head assembly 260 opposite the electric motor 262 is the front axle differential 214 of the front axle system 204.

FIGS. 6-6F provide a schematic illustration of an axle assembly 300 having a modular electric axle head assembly 302 according to an embodiment of the disclosure. As best seen in FIGS. 6 and 6B of the disclosure, the axle assembly 300 has a first axle half shaft housing 304, a second axle half shaft housing 306 and a banjo portion 308 interposed between the first and second axle half shaft housings 304 and 306. As a non-limiting example, the axle assembly 300 may be a front axle assembly, a rear axle assembly, a forward tandem axle assembly and/or a rear tandem axle assembly. Additionally, it is within the scope of this disclosure and as a non-limiting example, that the axle assembly 300 may be a conventional axle assembly having the modular electric axle head assembly 302.

The first axle half shaft housing 304 has an inner surface 310, an outer surface 312, a first end portion 314 and a second end portion 316. As best seen in FIG. 6B of the disclosure, the inner surface 310 and the outer surface 312 of the first axle half shaft housing 304 defines a hollow

portion **318** therein. The hollow portion **318** of the first axle half shaft housing **304** of the axle assembly **300** may have a size and shape to receive at least a portion of a first axle half shaft **319**.

Integrally connected to at least a portion of the outer surface **310** of the first end portion **314** of the first axle half shaft housing **304** is a first flange **320**. According to an embodiment of the disclosure and as a non-limiting example, the first flange **320** may be integrally connected to the first end portion **314** of the first axle half shaft housing **304** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first flange **320** may be integrally formed as part of the first end portion **314** of the first axle half shaft housing **304**.

Disposed outward from the first flange **320** is a first spindle **322**. The first spindle **322** provides rotational support for a first wheel end assembly (not shown). As best seen in FIGS. **6** and **6**B of the disclosure, the first spindle **322** may be integrally connected to at least a portion of the first end portion **314** of the first axle half shaft housing **304**. According to an embodiment of the disclosure and as a non-limiting example, the first spindle **322** may be integrally connected to the first end portion **314** of the first axle half shaft housing **304** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first spindle **322** may be integrally formed as part of the first end portion **314** of the first axle half shaft housing **304**.

Integrally connected to at least a portion of the second end portion **316** of the first axle half shaft housing **304** is an end of the banjo portion **308** of the axle assembly **300**. It is within the scope of this disclosure and as a non-limiting example, that the second end portion **316** of the first axle housing **304** may form at least a portion of the banjo portion **308** of the axle assembly **300**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the second end portion **316** of the first axle half shaft housing **304** may be connected to the end of the banjo portion **308** of the axle assembly **300** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners.

As best seen in FIG. **6**B of the disclosure, the second axle half shaft housing **306** has an inner surface **324**, an outer surface **326**, a first end portion **328** and a second end portion **330**. The inner surface **324** and the outer surface **326** of the second axle half shaft housing **306** defines a hollow portion **332** therein. The hollow portion **332** of the second axle half shaft housing **306** of the axle assembly **300** may have a size and shape to receive at least a portion of a second axle half shaft **333**.

Integrally connected to at least a portion of the first end portion **328** of the second axle half shaft housing **306** is an end of the banjo portion **308** of the axle assembly **300** opposite the first axle half shaft housing **304**. It is within the scope of this disclosure and as a non-limiting example, that the first end portion **328** of the second axle housing **306** may form at least a portion of the banjo portion **308** of the axle assembly **300**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first end portion **328** of the second axle half shaft housing **306** may be connected to the end of the banjo portion **308** of the axle assembly **300** opposite the first axle half shaft housing **304** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners.

At least a portion of a second flange **334** may be integrally connected to at least a portion of the outer surface **324** of the second end portion **330** of the second axle half shaft housing **306** of the axle assembly **300**. According to an embodiment of the disclosure and as a non-limiting example, the second flange **334** may be integrally connected to the second end portion **330** of the second axle half shaft housing **306** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the second flange **330** may be integrally formed as part of the second end portion **330** of the second axle half shaft housing **306**.

Disposed outward from the second flange **334** is a second spindle **336**. The second spindle **336** provides rotational support for a second wheel end assembly (not shown). As best seen in FIGS. **6** and **6**B of the disclosure, the second spindle **336** may be integrally connected to at least a portion of the second end portion **330** of the second axle half shaft housing **306**. According to an embodiment of the disclosure and as a non-limiting example, the second spindle **336** may be integrally connected to the second end portion **330** of the second axle half shaft housing **306** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the second spindle **226** may be integrally formed as part of the second end portion **330** of the second axle half shaft housing **306** of the axle assembly **300**.

As best seen in FIG. **6**B of the disclosure, the banjo portion **308** of the axle assembly **300** has an outer surface **338**, an inner surface **340**, an inboard side **342** and an outboard side **344**. The outer surface **338** and the inner surface **340** of the banjo portion **308** of the axle assembly **300** defines a hollow portion **346** therein. The hollow portion **346** of the banjo portion **308** of the axle assembly **300** may have a size and shape to receive and retain at least a portion of the modular electric axle head assembly **302**.

Extending from the outer surface **338** to the inner surface **340** of the inboard side **342** of the banjo portion **308** of the axle assembly **308** is a first opening **348**. As best seen in FIG. **6**B of the disclosure, the first opening **348** in the inboard side **342** of the banjo portion **308** of the axle assembly **300** may have a size and a shape to receive at least a portion of the modular electric axle head assembly **302**.

Additionally, extending from the outer surface **338** to the inner surface **340** of the outboard side **344** of the banjo portion **308** of the axle assembly **300** is a second opening **350**. As best seen in FIG. **6** of the disclosure, the second opening **350** in the outboard side **344** of the banjo portion **308** of the axle assembly **300** may have a size and a shape to receive at least a portion of the modular electric axle head assembly **302**.

Integrally connected to at least a portion of the outer surface **338** of the outboard side **344** of the banjo portion **308** of the axle assembly **300** is a cover **352**. At least a portion of the cover **354** sealingly engages at least a portion of the outer surface **338** of the outboard side **344** of the banjo portion **308** of the axle assembly **300**. The sealing engagement between the cover **352** and the outer surface **338** of the outboard side **344** of the banjo portion **308** prevents the migration of dirt, debris and/or moisture into the hollow portion **346** of the banjo portion **308** of the axle assembly **300**. It is within the scope of this disclosure and as a

non-limiting example, that the axle assembly **300** may further include the use of a gasket (not shown) to aid in facilitating the sealing engagement between the outer surface **338** of the outboard side **344** of the banjo portion **308** and the cover **352** of the axle assembly **300**. The gasket (not shown) will fill any gaps between the outer surface **338** of the outboard side **344** of the banjo portion **308** and the cover **352** when assembled. In accordance with an embodiment of the disclosure and as a non-limiting example, the cover **352** may be integrally connected to at least a portion of the outboard side **344** of the banjo portion **308** of the axle assembly **300** by using one or more adhesives, one or more welds, a threaded connection and/or one or more mechanical fasteners.

The cover **352** may have a size and shape to receive at least a portion of the modular electric axle head assembly **302**. According to the embodiment of the disclosure illustrated in FIGS. **6** and **6**B of the disclosure and as a non-limiting example, the cover **352** may be substantially disk-shaped member having a protruding portion **354**.

As best seen in FIGS. **6**, **6**B, **6**C and **6**D of the disclosure, the modular electric axle head assembly **302** includes a motor **356** that is drivingly connected to an end of a motor output shaft **358**. The motor **356** may be in electrical communication with a source of electrical power (not shown) to provide the rotational power necessary to drive the wheels (not shown) of the axle assembly **300**. As a non-limiting example that the motor **356** may be an electric motor or any other device that is able to convert an amount of electrical energy into an amount of mechanical energy.

It is within the scope of this disclosure and as a non-limiting example that the motor **356** may be capable of acting as a generator when not providing the rotations power needed to drive the modular electric axle had assembly **302**. As a result, it is to be understood that the power generated by the motor **356** when acting as a generator may be stored for later use.

Integrally connected to at least a portion of the outer surface **338** of the inboard side **342** of the banjo portion **308** of the axle assembly **300** is a gear assembly housing **360** having an inner surface **362**, an outer surface **364**, a first end portion **366**, a second end potion **368**, an inboard portion **370**, an outboard portion **372** and an intermediate portion **374** interposed between the inboard and outboard portions **370** and **372** of the gear assembly housing **360**. As best seen in FIGS. **6**A and **6**B of the disclosure, the inner surface **362** and the outer surface **364** of the gear assembly housing **360** defines a hollow portion **376** therein. The hollow portion **376** of the gear assembly housing **360** may have a size and a shape to receive and retain at least a portion of a gear assembly **378**. In accordance with an embodiment of the disclosure and as a non-limiting example, the hollow portion **376** of the gear assembly housing **360** may have a substantially triangular cross-sectional shape.

A flange portion **380** extends outward from at least a portion of the outer surface **364** of the second end portion **368** of the inboard portion **370** of the gear assembly housing **360**. The flange portion **380** second end portion **368** of the gear assembly housing **360** has one or more apertures **384** extending from a first end **386** to a second end **388** of the flange portion **308** of the gear assembly housing **360**. As best seen in FIG. **6**A of the disclosure, the one or more apertures **384** of the flange portion **380** of the second end portion **368** of the gear assembly housing **360** are of a size and shape to receive and/or retain one or more mechanical fasteners **390**. It is therefore within the scope of this disclosure and as a non-limiting disclosure that the one or more apertures **382** may have a plurality of axially extending threads (not shown) that are complementary to a plurality of axially extending threads (not shown) on the one or more mechanical fasteners **390**. According to an embodiment of the disclosure and as a non-limiting example, the flange portion **380** of the second end portion **368** of the gear assembly housing **360** may be substantially triangular in shape.

Interposed between the gear assembly housing **360** and the motor **356** is a motor mounting member **392**. As best seen in FIGS. **6**C and **6**D of the disclosure, the motor mounting member **392** has a first side **394**, a second side **396**, an inboard portion **398** and an outboard portion **400**. The motor mounting member **392** may be a modular member having a size and shape to needed to mount the motor **356** to at least a portion of the second end portion **368** of the gear assembly housing **360** of the modular electric axle head assembly **302**. It is within the scope of this disclosure, that the shape of the motor mounting member **392** may change depending on the type of motor used and the shape of the motor used in the modular electric axle head assembly **302**. As a non-limiting example and as best seen in FIGS. **6**C and **6**D of the disclosure, the motor mounting member **392** may be substantially triangular in shape having a first substantially straight side **402**, a second substantially straight side **404** and a third substantially straight side **406**. Additionally, as a non-limiting example and as best seen in FIGS. **6**C and **6**D of the disclosure and as a non-limiting example, the third substantially straight side **406** of the motor mounting member **392** has an arcuate portion **408** having a radius R**1** and extending into the motor mounting member **392**.

According to the embodiment of the disclosure illustrated in FIGS. **6**-**6**D and **6**F and as a non-limiting example, a motor mounting portion **410** extends outward from at least a portion of the second side **396** of the motor mounting member **392**. It is within the scope of this disclosure and as a non-limiting example that the motor mounting portion **410** may have a substantially cylindrical shape that is complementary to a mounting portion **412** of the motor **356**.

Extending from a first side **394** to a second side **396** of the motor mounting portion **410** of the motor mounting member **392** is a motor mounting member opening **415**. It is within the scope of this disclosure and as a non-limiting example that the motor mounting member opening **415** may have a size and a shape to receive at least a portion of the motor output shaft **358** of the motor **356**.

Additionally, extending from a first side **394** to a second side **396** of the motor mounting portion **410** of the motor mounting member **392** is one or more motor attachment apertures **414**. As best seen in FIGS. **6***c* and **6**D of the disclosure and as a non-limiting example, the one or more motor attachment apertures **414** of the motor mounting portion **410** of the motor mounting member **392** are disposed circumferentially along the outer periphery of the motor mounting member **392**. The one or more motor attachment apertures **414** are of a size and a shape to receive and/or retain one or more mechanical fasteners **416**. It is therefore within the scope of this disclosure and as a non-limiting disclosure that the one or more motor attachment apertures **414** of motor mounting portion **410** may have a plurality of axially extending threads (not shown) that are complementary to a plurality of axially extending threads (not shown) on the one or more mechanical fasteners **416**.

In order to secure the motor mounting member **392** to the motor **356**, at least a portion of the one or more mechanical fasteners **416** are received and retained within at least a portion of one or more attachment apertures **418**. As best seen in FIG. **6**D of the disclosure, the one or more attach-

ment apertures **418** in the motor **356** are complementary to the one or more motor attachment apertures **414** in the motor mounting portion **410** of the motor mounting member **392**. According to an embodiment of the disclosure and as a non-limiting example, the one or more attachment apertures **418** of the motor **356** have a plurality of axially extending threads (not shown) that are complementary to the plurality of axially extending threads (not shown) on the one or more mechanical fasteners **416**.

Extending from the first end side to the second side **396** of the motor mounting member **392** is one or more gear housing attachment apertures **420** that are complementary to the one or more apertures **384** in the flange portion **380** of the second end portion **368** of the gear assembly housing **360**. As best seen in FIGS. **6**C and **6**D of the disclosure and as a non-limiting example, the one or more gear housing attachment apertures **420** are disposed along the outer periphery of the first, second and/or third substantially straight sides **402**, **404** and/or **406** of the motor mounting member **392**. The one or more gear housing attachment apertures **420** are of a size and shape to receive and retain the one or more mechanical fasteners **390**. According to an embodiment of the disclosure and as a non-limiting example, the gear housing attachment apertures **420** of the motor mounting member **392** have a plurality of axially extending threads (not shown) that are complementary to the plurality of axially extending threads (not shown) on the one or more mechanical fasteners **390**. When assembled, at least a portion of the first side **394** of the motor mounting member **392** may be in direct contact with at least a portion of a second end **421** of the gear assembly housing **360** of the modular electric axle head assembly **302**.

A flange portion **422** extends outward from at least a portion of the outer surface **364** of the first end portion **366** of the gear assembly housing **360**. The flange portion **422** first end portion **366** of the gear assembly housing **360** has one or more apertures **424** extending from a first end **426** to a second end **428** of the flange portion **422** of the gear assembly housing **360**. As best seen in FIG. **6**A of the disclosure, the one or more apertures **424** of the flange portion **422** of the first end portion **366** of the gear assembly housing **360** are of a size and shape to receive and retain one or more mechanical fasteners **430**. It is therefore within the scope of this disclosure and as a non-limiting disclosure that the one or more apertures **424** may have a plurality of axially extending threads (not shown) that are complementary to a plurality of axially extending threads (not shown) on the one or more mechanical fasteners **430**. In accordance with an embodiment of the disclosure and as a non-limiting example, the flange portion **422** of the first end portion **366** of the gear assembly housing **360** may be substantially triangular in shape.

Extending from the inner surface **362** to the outer surface **364** of a first end **432** of the gear assembly housing **360** is an opening **434**. The opening **434** in the first end **432** of the gear assembly housing **360** has a size and shape necessary to facilitate the assembly of the gear assembly **378** within the hollow portion **376** of the gear assembly housing **360**.

Disposed outward from at least a portion of the first end **432** of the gear assembly housing **360** is a gear housing cover **436** having a first side **438** and a second side **440**. The gear housing cover **436** may have a size and shape needed to seal the opening **434** of the first end **432** of the gear assembly housing **360** from the migration of first, debris and/or moisture into the hollow portion **376** of the gear assembly housing **360**. Additionally, the gear housing cover **436** may be selectively removable providing access to the gear assembly **378** to make repairs, replacements and/or modifications to one or more of the components of the modular electric axle head assembly **302**. In accordance with an embodiment of the disclosure and as a non-limiting example, the gear housing cover **436** may have a shape that is complementary to the flange portion **422** of the first end portion **366** of the gear assembly housing **360**. It is therefore within the scope of this disclosure and as a non-limiting example, that the gear housing cover **436** may have a substantially triangular shape.

Extending from the first side **438** to the second side **440** of the gear housing cover **436** is one or more apertures **442** that are complementary to the one or more apertures **424** in the flange portion **422** of the first end portion **366** of the gear assembly housing **360**. As best seen in FIG. **6**A of the disclosure and as a non-limiting example the one or more apertures **442** of the gear housing cover **436** are disposed along the outer periphery of the gear housing cover **436**. The one or more apertures **442** of the gear housing cover **436** are of a size and shape to receive and/or retain the one or more mechanical fasteners **430**. It is therefore within the scope of this disclosure and as a non-limiting example, the one or more apertures **442** of the gear housing cover **436** may include a plurality of axially extending threads (not shown) that are complementary to the plurality of axially extending threads (not shown) on the one or more mechanical fasteners **430**. When assembled, at least a portion of the second side **440** of the gear housing cover **436** may be in direct contact with at least a portion of the first end **432** of the gear assembly housing **360** of the modular electric axle head assembly **302**.

A motor output shaft opening **444** extends from the outer surface **364** to the inner surface **362** of the second end **421** of the gear assembly housing **360**. The motor output shaft opening **444** may have a size and a shape needed to receive and/or retain at least a portion of the motor output shaft **358** of the motor **356**.

Extending co-axially and drivingly connected with the motor output shaft **358** of the motor **356** is a first gear shaft **446** having a first end portion **448**, a second end portion **450** and an outer surface **452**. As best seen in FIGS. **6**A and **6**B of the disclosure, at least a portion of the first end portion **448** of the first gear shaft **446** may be received within one or more first bearing assemblies **454** disposed within a first receiving portion **456** in an outboard portion **458** of the second side **440** of the gear housing cover **436**. As a non-limiting example, the one or more first bearing assemblies **454** may be one or more tapered roller bearings, one or more rolling element bearings, one or more needle bearings, one or more magnetic bearings and/or one or more bushings.

Connected to at least a portion of the outer surface **452** of the first end portion **448** of the first gear shaft **446** is a first gear **460**. Circumferentially extending from at least a portion of an outer surface **462** of the first gear **460** is a plurality of first gear teeth **464**. According to an embodiment of the disclosure and as a non-limiting example, the first gear **460** may be integrally formed as part of the first end portion **448** of the first gear shaft **446**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first gear **460** may be integrally connected to at least a portion of the first end portion **448** of the first gear shaft **446** by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection. It is within the scope of this disclosure and as a non-limiting example that the first gear **460** may be a first reduction gear for the gear assembly **378** of the modular electric axle head assembly **302**. As a

non-limiting example, the plurality of first gear teeth **464** extending from the outer surface **462** of the first gear **460** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

As illustrated in FIGS. **6**A and **6**B of the disclosure, at least a portion of the second end portion **450** of the first gear shaft **446** has a hollow interior portion **466** extending inward from a second end **468** of the first gear shaft **446**. The hollow interior portion **466** of the second end portion **450** of the first gear shaft **446** may have a size and shape needed to receive and/or retain at least a portion of the motor output shaft **358**. In accordance with an alternative embodiment of the disclosure (not shown), the second end portion of the first gear shaft may be connected to at least a portion of the motor output shaft of the motor by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection.

Circumferentially extending along at least a portion of an inner surface **470** defining the hollow interior portion **466** of the second end portion **450** of the first gear shaft **446** is a plurality of axially extending splines **472**. The plurality of axially extending splines **472** are complementary to and meshingly engaged with a plurality of axially extending splines **474** on an outer surface **476** of the motor output shaft **358**. The meshing engagement of the plurality of axially extending splines **472** and **474** of the first gear shaft **446** and the motor output shaft **358** rotationally fixes the first gear shaft **446** to the motor output shaft **358**.

In accordance with the embodiment of the disclosure illustrated in FIGS. **6**A and **6**B of the disclosure, at least a portion of the second end portion **450** of the first gear shaft **466** may be received within one or more second bearing assemblies **478** in the motor output shaft opening **444** of the second end **421** of the gear assembly housing **360**. As a non-limiting example, the one or more second bearing assemblies **478** may be one or more tapered roller bearings, one or more rolling element bearings, one or more needle bearings, one or more magnetic bearings and/or one or more bushings.

Extending parallel with the first gear shaft **446** and the motor output shaft **358** of the modular electric axle head assembly **302** is a second gear shaft **480** having a first end portion **482**, a second end portion **484** and an outer surface **486**. As best seen in FIGS. **6**A and **6**B of the disclosure, at least a portion of the first end portion **482** of the second gear shaft **480** may be received within one or more third bearing assemblies **488** disposed within a second receiving portion **490** in an outboard portion **492** of the second side **440** of the gear housing cover **436**. Additionally, as best seen in FIGS. **6**A and **6**B of the disclosure, at least a portion of the second end portion **484** of the second gear shaft **480** may be received within one or more fourth bearing assemblies **494** disposed within a receiving portion **496** in the inner surface **362** of the outboard portion **372** of the second end portion **368** of the gear assembly housing **360**. As a non-limiting example, the one or more bearing assemblies **488** and **494** of the modular electric axle head assembly **302** may be one or more tapered roller bearings, one or more rolling element bearings, one or more needle bearings, one or more magnetic bearings, one or more cylindrical roller bearings and/or one or more bushings.

As best seen in FIG. **6**B of the disclosure and as a non-limiting example, the first and second axle half shafts **319** and **333** have a centerline Cl, the first gear shaft **446** has a centerline C**2** and the second gear shaft **480** has a centerline C**3**. It is within the scope of this disclosure and as a non-limiting example that a linear distance LD**1** between the centerline C**2** of the first gear shaft **446** and the centerline C**3** of the second gear shaft **480** may be less than a linear distance LD**2** between the centerline C**3** of the second gear shaft **480** and the centerline Cl of the first and second axle half shafts **319** and **333**.

Connected to at least a portion of the outer surface **486** of the first end portion **482** of the second gear shaft **480** is a second gear **498**. Circumferentially extending from at least a portion of an outer surface **500** of the second gear **498** is a plurality of second gear teeth **502** that are complementary to and meshingly engaged with the plurality of first gear teeth **464** on the first gear **460**. According to an embodiment of the disclosure and as a non-limiting example, the second gear **498** may be integrally formed as part of the first end portion **482** of the second gear shaft **480**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the second gear **498** may be integrally connected to, at least a portion of the first end portion **482** of the second gear shaft **480** by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection. It is within the scope of this disclosure and as a non-limiting example that the second gear **498** may be an intermediate gear for the gear assembly **378**. As a non-limiting example, the plurality of second gear teeth **502** extending from the outer surface **500** of the second gear **498** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

Connected to at least a portion of the second end portion **484** of the second gear shaft **480** is a third gear **504**. Circumferentially extending from at least a portion of an outer surface **506** of the third gear **504** is a plurality of third gear teeth **508**. According to an embodiment of the disclosure and as a non-limiting example, the third gear **504** may be integrally formed as part of the second end portion **484** of the second gear shaft **480**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the third gear **504** may be integrally connected to at least a portion of the second end portion **484** of the second gear shaft **480** by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection. It is within the scope of this disclosure and as a non-limiting example that the third gear **504** of the gear assembly **378** may be a second reduction gear. As a non-limiting example, the plurality of third gear teeth **508** extending from the outer surface **506** of the third gear **504** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

Meshingly engaged with at least a portion of the third gear **504** is a differential ring gear **510** of a differential assembly **512**. As best seen in FIGS. **6**A and **6**B of the disclosure, the differential ring gear **510** has a first side **514**, a second side **516** and an outer surface **518**. Circumferentially extending along at least a portion of the outer surface **518** of the differential ring gear **510** is a plurality of ring gear teeth **520** that are complementary to and meshingly engaged with the plurality of third gear teeth **508** on the outer surface **506** of the third gear **504**. It is within the scope of this disclosure and as a non-limiting example, the plurality of gear ring teeth **520** extending from the outer surface **518** of the differential ring gear **510** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear

teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

Circumferentially extending from at least a portion of the outer surface **364** of the outboard portion **372** of the gear assembly housing **360** is an axle assembly mounting flange **530** having an inboard portion **532** and an outboard portion **534**. The axle assembly mounting flange **530** may have a size and shape needed to sealingly engage with the first opening **348** in the inboard side **342** of the banjo portion **308** of the axle assembly **300**. The sealing engagement between the axle assembly mounting flange **530** and the outer surface **338** of the inboard side **342** of the banjo portion **308** prevents the migration of dirt, debris and/or moisture into the hollow portion **346** of the banjo portion **308** of the axle assembly **300**. It is within the scope of this disclosure and as a non-limiting example, that the axle assembly **300** may further include the use of a gasket or supporting ring **536** to aid in facilitating the sealing engagement between the outer surface **338** of the banjo portion **308** and the outboard portion **534** of the axle assembly mounting flange **530**. The gasket or supporting ring **536** will fill any gaps between the outer surface **338** of the inboard side **342** of the banjo portion **308** and outboard portion **534** of the axle assembly mounting flange **530** when assembled. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the axle assembly mounting flange **530** may be integrally connected to at least a portion of the inboard side **342** of the banjo portion **308** by using one or more mechanical fasteners **538**. According to an alternative embodiment of the disclosure (not shown) and as a non-limiting example, at least a portion of the outboard portion **534** of the axle assembly mounting flange **530** may be integrally connected to at least a portion of the inboard side **342** of the banjo portion **308** by using one or more adhesives, one or more welds and/or a threaded connection. It is within the scope of this disclosure that the one or more adhesives, one or more welds and/or a threaded connection may be used in combination with or instead of the one or more mechanical fasteners **538**.

Extending from at least a portion of the outboard portion **534** of the axle assembly mounting flange **530** of the gear assembly housing **360** is a first protruding portion **540** and a second protruding portion **542**. As best seen in FIGS. **6**D, **6**E and **6**F, the first and second protruding portions **540** and **542** of the axle assembly mounting flange **530** of the gear assembly housing **360** are disposed on axially opposing sides of the axle assembly mounting flange **530**. The first and second protruding portions **540** and **542** of the axle assembly mounting flange **530** of the gear assembly housing **360** provide rotational support or at least a portion of the differential assembly **512**.

Extending from the first side **514** to the second side **516** of the differential ring gear **510** is one or more apertures **544**. The one or more apertures **544** in the differential ring gear **510** are of a size and shape to receive and/or retain at least a portion of one or more mechanical fasteners **546**. It is therefore within the scope of this disclosure and as a non-limiting disclosure that the one or more apertures **544** may have a plurality of axially extending threads (not shown) that are complementary to a plurality of axially extending threads (not shown) on the one or more mechanical fasteners **546**.

Extending outward from at least a portion of the first side **514** of the differential ring gear **510** is an axially protruding portion **548**. As best seen in FIGS. **6**A, **6**B and **6**F of the disclosure, at least a portion of the axially protruding portion **548** may be received within one or more fifth bearing assemblies **552** disposed within an arcuate portion **554** of the first protruding portion **540** of the axle assembly mounting flange **530** of the gear assembly housing **360**. As a result, at least a portion of the arcuate portion **554** of the first protruding portion **540** of the axle assembly mounting flange **530** provides rotational support for the axially protruding portion **548** of the differential ring gear **510**. It is within the scope of this disclosure and as a non-limiting example that the one or more fifth bearing assemblies **552** may be one or more tapered roller bearings, one or more rolling element bearings, one or more needle bearings, one or more magnetic bearings and/or one or more bushings.

The axially protruding portion **548** of the differential ring gear **510** has a hollow interior portion **550** having a size and shape to receive at least a portion of an end of the first axle half shaft **319**. As best seen in FIGS. **6**A and **6**B of the disclosure and as a non-limiting example, the axially protruding portion **548** and the hollow interior portion **550** of the differential ring gear **510** are substantially cylindrical in shape.

Disposed outward from at least a portion of the second side **516** of the differential ring gear **510** is a differential case **556**. As best seen in FIGS. **6**A and **6**B of the disclosure, the differential case **556** has an inner surface **558**, an outer surface **560**, a first end portion **562**, a second end portion **564** and an intermediate portion **566** disposed between the first and second end portions **562** and **564** of the differential case **556**. The inner surface **558** and the outer surface **560** of the differential case **556** defines a hollow interior portion **568** therein. As illustrated in FIGS. **6**A and **6**B of the disclosure, at least a portion of the first end portion **562** of the differential case **556** may be integrally connected to at least a portion of the second side **516** of the differential ring gear **510**. In accordance with an embodiment of the disclosure and as a non-limiting example, the first end portion **562** of the differential case **556** may be integrally connected to the second side **516** of the differential ring gear **510** by receiving and retaining at least a portion of the one or more mechanical fasteners **546** within one or more mechanical fastener receiving portions **570**. It is therefore within the scope of this disclosure and as a non-limiting disclosure that the one or more mechanical fastener receiving portions **570** may have a plurality of axially extending threads (not shown) that are complementary to a plurality of axially extending threads (not shown) on the one or more mechanical fasteners **546**.

The second end portion **564** of the differential case **556** has a reduced diameter portion **572**. As best seen in FIGS. **6**A, **6**B and **6**F of the disclosure, at least a portion of the reduced diameter portion **572** of the differential case **556** may be received within one or more sixth bearing assemblies **574** disposed within an arcuate portion **576** of the second protruding portion **542** of the of the axle assembly mounting flange **530**. As a result, at least a portion of the arcuate portion **576** of the second protruding portion **542** of the axle assembly mounting flange **530** provides rotational support for the reduced diameter portion **572** of the differential case **556**. In a non-limiting example, the one or more sixth bearing assemblies **574** may be one or more tapered roller bearings, one or more rolling element bearings, one or more needle bearings, one or more magnetic bearings and/or, one or more bushings.

The reduced diameter portion **572** of the differential case **556** has a hollow interior portion **576** having a size and shape to receive at least a portion of an end of the second axle half shaft **333**. As best seen in FIGS. **6**A and **6**B of the disclosure and as a non-limiting example, the reduced diam-

eter portion **572** and the hollow interior portion **576** of the differential case **556** are substantially cylindrical in shape.

The differential assembly **512** further includes one or more spider gears **578** rotatively connected to a cross pin **580**. As illustrated in FIGS. **6**A and **6**B of the disclosure, at least a portion of each end of the cross pin **580** may be integrally connected to the differential case **556** of the differential assembly **512**. Circumferentially extending from at least a portion of an outer surface **582** of the one or more spider gears **578** is a plurality of spider gear teeth **584**. As a non-limiting example, the plurality of spider gear teeth **584** extending from the outer surface **582** of the one or more spider gears **578** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

Drivingly connected to at least a portion of the one or more spider gears **578** is a first side gear **586** of the differential assembly **512**. Circumferentially extending from at least a portion of an outer surface **588** of the first side gear **586** is a plurality of first side gear teeth **590** that are complementary to and meshingly engaged with the plurality of spider gear teeth **584** on the outer surface **582** of the one or more spider gears **578**.

As best seen in FIGS. **6**A and **6**B of the disclosure, circumferentially extending from at least a portion of an inner surface **592** of the first side gear **586** is a plurality of axially extending splines **594**. The plurality of axially extending splines **594** of the first side gear **586** are complementary to and meshingly engaged with a plurality of axially extending splines **596** on an outer surface **598** of the end first axle half shaft **319** of the axle assembly **300**. As a result, the meshing engagement of the plurality of axially extending splines **594** and **596** on the first side gear **586** and the first axle half shaft **319** drivingly connects the first side gear **586** to the first axle half shaft **319**.

Drivingly connected to at least a portion of the one or more spider gears **578** is a second side gear **600** of the differential assembly **512**. As best seen in FIGS. **6**A and **6**B of the disclosure, the first and second side gears **586** and **600** are disposed on axially opposing sides of the one or more spider gears **578** of the differential assembly **512**. Circumferentially extending from at least a portion of an outer surface **602** of the second side gear **600** is a plurality of second side gear teeth **604** that are complementary to and meshingly engaged with the plurality of spider gear teeth **584** on the outer surface **582** of the one or more spider gears **578**.

As best seen in FIGS. **6**A and **6**B of the disclosure, circumferentially extending from at least a portion of an inner surface **606** of the second side gear **600** is a plurality of axially extending splines **608**. The plurality of axially extending splines **608** of the second side gear **600** are complementary to and meshingly engaged with a plurality of axially extending splines **610** on an outer surface **612** of the end second axle half shaft **333** of the axle assembly **300**. As a result, the meshing engagement of the plurality of axially extending splines **608** and **610** on the second side gear **600** and the second axle half shaft **333** drivingly connects the second side gear **600** to the second axle half shaft **333**.

In accordance with the embodiment of the disclosure illustrated in FIGS. **6**A and **6**B of the disclosure, when assembled, at least a portion of the first protruding portion **540**, the second protruding portion **542**, the differential ring gear **510** and the differential assembly **512** is disposed within the hollow portion **346** of the banjo portion **308** of the axle assembly **300**.

FIGS. **7**-**7**B provide a schematic illustration of the axle assembly **300** illustrated in FIGS. **6**-**6**F of the disclosure having a modular electric axle head assembly **702** according to an alternative embodiment of the disclosure. The axle assembly **300** and the modular electric axle head assembly **702** illustrated in FIGS. **7**-**7**B are the same as the axle assembly **300** and the modular electric axle head assembly **302** illustrated in FIGS. **6**-**6**F, except where specifically noted below. In accordance with the embodiment of the disclosure illustrated in FIGS. **7**-**7***b,* the modular electric axle head assembly **702** includes the use of a brake assembly **701** that may be integrally connected to at least a portion of an end of a first gear shaft **700**.

As best seen in FIG. **7**B of the disclosure, the first gear shaft **700** of the modular electric axle head assembly **702** has an outer surface **703**, a first end portion **704**, a second end portion **706** and an intermediate portion **708** disposed between the first and second end portions **704** and **706** of the first gear shaft **700**. The first gear shaft **700** extends co-axially with the motor output shaft **358** and the second gear shaft **480** of the gear assembly **378'**.

In accordance with the embodiment of the disclosure illustrated in FIG. **7**B, at least a portion of the second end portion **706** of the first gear shaft **700** may be received within the one or more second bearing assemblies **478** disposed within the motor output shaft opening **444** of the second end **421** of the gear assembly housing **360**.

At least a portion of the second end portion **706** of the first gear shaft **700** has a hollow interior portion **710** extending inward from a second end **712** of the first gear shaft **700**. The hollow interior portion **710** of the second end portion **706** of the first gear shaft **700** may have a size and shape to receive and/or retain at least a portion of the motor output shaft **358** of the motor **356**.

Circumferentially extending along at least a portion of an inner surface **714** defining the hollow interior portion **710** of the second end portion **706** of the first gear shaft **700** is a plurality of axially extending splines **716**. The plurality of axially extending splines **716** are complementary to and meshingly engaged with a plurality of axially extending splines **718** on an outer surface **720** of the motor output shaft **358**. The meshing engagement of the plurality of axially extending splines **716** and **718** of the first gear shaft **700** and the motor output shaft **358** rotationally fixes the first gear shaft **446** to the motor output shaft **358**.

As illustrated in FIG. **7**B of the disclosure, at least a portion of the first end portion **704** of the first gear shaft **700** extends through an opening **722** extending from a first side **438** to a second side **440** of the outboard portion **458** of the gear housing cover **436**. Disposed within the opening **722** of the gear housing cover **436** is the one or more first bearing assemblies **454** having a size and shape to receive and rotationally support at least a portion of the first gear shaft **700**.

In accordance with the embodiment of the disclosure illustrated in FIG. **7**B, at least a portion of the outer surface **703** of the first end portion **704** of the first gear shaft **700** has a plurality of axially extending threads **724**.

Circumferentially extending along at least a portion of the outer surface **703** of the first gear shaft **700** is a plurality of axially extending splines **726**. As best seen in FIG. **7**B of the disclosure, the plurality of axially extending splines **726** are disposed directly adjacent to the plurality of axially extending threads **724** on the first end portion **704** of the first gear shaft **700**. In accordance with an embodiment of the disclosure and as a non-limiting example, at least a portion of the

plurality of axially extending splines **726** extend outward from the first side **438** of the gear housing cover **436**.

Connected to at least a portion of the outer surface **703** of the intermediate portion **708** of the first gear shaft **700** is a first gear **728**. As best seen in FIG. **7**B of the disclosure, the first gear **728** may be disposed adjacent to a side of the plurality of splines **726**, opposite the plurality of threads **724**, on the outer surface **703** of the first gear shaft **700** and within the hollow portion **376** of the gear assembly housing **360**. Circumferentially extending from at least a portion of an outer surface **730** of the first gear **728** is a plurality of first gear teeth **732** that are complementary to and meshingly engaged with the plurality of second gear teeth **502** on the second gear **498**. According to an embodiment of the disclosure and as a non-limiting example, the first gear **728** may be integrally formed as part of the first gear shaft **700** of the gear assembly **378'**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first gear **728** may be integrally connected to at least a portion of the first gear shaft **700** by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection. It is within the scope of this disclosure and as a non-limiting example that the first gear **728** may be a first reduction gear of the gear assembly **378'** of the modular electric axle head assembly **702**. As a non-limiting example, the plurality of first gear teeth **732** extending from the outer surface **730** of the first gear **728** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

Extending co-axially with the first gear shaft **700** is a rotor portion **734** of the brake assembly **701** having an inner surface **736**, an outer surface **738**, a first end portion **740** and a second end portion **742**. As best seen in FIG. **7**B of the disclosure, at least a portion of the first end portion **740** of the rotor portion **734** is disposed outside the hollow interior portion **376** of the gear assembly housing **360** of the modular electric axle head assembly **302**. Additionally, as best seen in FIG. **7**B of the disclosure, at least a portion of the second end portion **742** of the rotor portion **734** is disposed within the hollow interior portion **376** of the gear assembly housing **360**.

Circumferentially extending from at least a portion of the inner surface **736** of the rotor portion **734** is a plurality of axially extending splines **744**. The plurality of axially extending splines **744** on the inner surface **736** of the rotor portion **734** are complementary to and meshingly engaged with the plurality of axially extending splines **726** on the outer surface **703** of the first end portion **704** of the first gear shaft **700**.

As illustrated in FIG. **7**B of the disclosure, circumferentially extending from at least a portion of the first end portion **740** of the rotor portion **734** is a first increased diameter portion **746** having a first side **748** and a second side **750**. In accordance with the embodiment illustrated in FIG. **7**B and as a non-limiting example, at least a portion of the first increased diameter portion **746** of the rotor portion **734** is disposed outside the hollow interior portion **376** of the gear assembly housing **360**. It is within the scope of this disclosure and as a non-limiting example that the first increased diameter portion **746** of the rotor portion **734** may be substantially disk-shaped.

Disposed directly adjacent to the second side **750** of the first increased diameter portion **746** of the rotor portion **734** is a second increased diameter portion **752**. As it can be seen by referencing FIG. **7**B of the disclosure and as a non-limiting example, the second increased diameter portion **752** has an outermost diameter that is less than an outermost diameter of the first increased diameter portion **746** of the rotor portion **734**.

Integrally connected to at least a portion of the outer surface **738** of the rotor portion **734** is a first sealing portion **754**. In accordance with an embodiment of the disclosure and as a non-limiting example, at least a portion of the first sealing portion **754** may be integrally connected to at least a portion of the outer surface **738** and to at least a portion of the second increased diameter portion **752** of the rotor portion **734**. As best seen in FIG.**7**B of the disclosure, the first sealing portion **754** is disposed directly adjacent to an end of the second increased diameter portion **752** opposite the first increased diameter portion **746** of the rotor portion **734** of the brake assembly **701**. Additionally, as best seen in FIG. **7**B of the disclosure, the first sealing portion **754** extends outward from at least a portion of the outer surface **738** of the rotor portion **734** beyond the opening **722** in the outboard portion **458** of the gear housing cover **436**. According to an embodiment of the disclosure (not shown), the first sealing portion **754** of the modular electric axle head assembly **702** may be integrally formed as part of the rotor portion **734**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first sealing portion **754** may be integrally connected to at least a portion of the outer surface **738** of the brake rotor by using one or more welds, one or more adhesives, one or more mechanical fasteners and/or using a threaded connection.

Integrally connected to at least a portion of an inner surface **756** defining the opening **722** in the outboard portion **458** of the gear housing cover **436** is a second sealing portion **758**. As a non-limiting example, at least a portion of the second sealing member **758** may be integrally connected to at least a portion of the inner surface **756** defining the opening **722** in the gear housing cover **436** and to at least a portion of the first side **438** of the gear housing cover **436**. As best seen in FIG. **7**B of the disclosure, at least a portion of the second sealing portion **758** extends inward from the inner surface **756** of the opening **722** toward the outer surface **738** of the rotor portion **734** of the brake assembly **701**.

At least a partially interposed between the second sealing portion **758** and the outer surface **738** of the rotor portion **734** is a sealing member **760** having one or more sealing ribs **762**. As best seen in FIG. **7**B of the disclosure, at least a portion of the second sealing portion **758** may be received within and sealingly engaged with at least a portion of the sealing member **760** of the modular electric axle head assembly **302**. Additionally, as illustrated in FIG. **7**B of the disclosure, at least a portion of the one or more sealing ribs **762** are sealingly engaged with at least a portion of the first sealing portion **754** and the rotor portion **734** of the modular electric axle head assembly **302**. As a result, the first sealing portion **754**, the second sealing portion **758** and the sealing member **760** aid in preventing the migration of dirt, debris and/or moisture into the hollow portion **376** of the gear assembly housing **360** of the modular electric axle head assembly **302**.

In accordance with an embodiment of the disclosure and as a non-limiting example, the sealing member **760** further includes one or more ring members **764** that are received within a channel **766** circumferentially extending along at least a portion of one or more of the one or more sealing ribs **762**. The one or more ring members **764** provide a radially compressive force to the one or more sealing ribs **762**, which aids in providing a sealing engagement between the sealing

member **760** and the rotor portion **734** of the modular electric axle head assembly **302**. As a result, the one or more ring members **764** further aid in preventing the migration of dirt, debris and/or moisture into the hollow portion **376** of the gear assembly housing **360**.

As best seen in FIGS. **7**A and **7**B of the disclosure and as a non-limiting example, the brake assembly **701** may include the use of a nut **768** and a washer **770** that are disposed directly adjacent to at least a portion of the rotor portion **734** of the brake assembly **701**. According to the embodiment illustrated in FIGS. **7**A and **7**B of the disclosure, at least a portion of the washer **770** is interposed between the nut **768** and the rotor portion **734** of the brake assembly **701**. It is within the scope of this disclosure and as a non-limiting example that the washer **770** may be a lock washer or any other type of retention device.

Circumferentially extending format least a portion of an inner surface **772** of the nut **768** is a plurality of axially extending threads **774**. As illustrated in FIG. **7**B of the disclosure, the plurality of axially extending threads **774** on the inner surface **772** of the nut **768** are complementary to and meshingly engaged with the plurality of axially extending threads **724** on the first end portion **704** of the first gear shaft **700**. When assembled, the nut **768** and/or the washer **770** are used to axially restrain the rotor portion **734** onto the first gear shaft **700** of the modular electric axle head assembly **302**.

Integrally connected to at least a portion of the flange portion **422** of the first end portion **366** of the gear assembly housing **360** and/or to at least a portion of the gear housing cover **436** of the modular electric axle head assembly **702** is a caliper assembly **776**. According to an embodiment of the disclosure and as a non-limiting example, the caliper assembly **776** of the brake assembly **701** may be integrally connected to the flange portion **422** of the gear assembly housing **360** and/or to the gear housing cover **436** by using one or more mechanical fasteners, one or more welds and/or one or more adhesives.

As best seen in FIG. **7**B of the disclosure, the caliper assembly **776** includes one or more pistons **778** that are connected to one or more brake pads **780**. It is within the scope of this disclosure that the one or more pistons **778** of the brake assembly **701** may be operable via a switch, mechanical linkage, a hydraulic system, a pneumatic system, an electro-mechanical system and/or a hybrid hydraulic-mechanical system. According to an embodiment of the disclosure and as a non-limiting example, the brake assembly **701** of the modular electric axle head assembly **702** may be a floating disk brake assembly or a fixed disk brake assembly. It is within the scope of this disclosure that the brake assembly **701** may function as a parking brake, a parking mechanism, an anti-theft mechanism and/or a service brake. As a result, it is therefore to be understood that the brake assembly **701** may be used alone or in combination with one or more braking assemblies (not shown) located at the first and/or second wheel end assemblies (not shown).

When the one or more pistons **778** are actuated, the one or more brake pads **780** are translated axially toward the first increased diameter portion **746** of the rotor portion **734** till the one or more brake pads **780** are at least variably frictionally engaged with the first increased diameter portion **746** of the rotor portion **734**. By selectively frictionally engaging the caliper assembly **776** with the first increased diameter portion **746** of the rotor portion **734**, the amount of rotational energy transmitted to the wheels (not shown) of the vehicle (not shown) can be limited. It is therefore within the scope of this disclosure that the brake assembly **701** may be used to aid in slowing down the vehicle (not shown), stopping the vehicle (not shown) and/or preventing the vehicle (not shown) from moving when parked.

In accordance with an embodiment of the disclosure and as a non-limiting example, the brake assembly **701** may further include the use of a braking assembly cover **782**. As best seen in FIG. **7** of the disclosure, the braking assembly cover **782** may have a size and shape needed to encase at least a portion of the rotor portion **734** and at least a portion of the caliper assembly **776**. The braking assembly cover **782** shields the rotor portion **734** and the caliper assembly **776** from damage due to road debris, loose road materials and/or any other materials that may damage the brake assembly **701** upon impact or may become lodged between the brake pads **780** and the rotor portion **734** inhibiting the function of the brake assembly **701**. Additionally, the braking assembly cover **782** shields the rotor portion **734** and the caliper assembly **776** from the accumulation of ice during the winter months which aids in improving the overall performance of the brake assembly **701** in low temperature operating conditions.

According to the embodiment of the disclosure illustrated in FIG. **7**, the braking assembly cover **782** may be integrally connected to at least a portion of the flange portion **422** of the gear assembly housing **360** and/or to at least a portion of the gear housing cover **436**. As illustrated in FIG. **7** of the disclosure, the braking assembly cover **782** may be integrally connected to at least a portion of a flange portion **784** extending outward from at least a portion of the outboard portion **458** of the gear housing cover **436**. The flange portion **784** of the gear housing cover **436** may have a shape that is complementary to the shape of the braking assembly cover **782**. As illustrated in FIG. **7** of the disclosure and as a non-limiting example, the flange portion **784** of the gear housing cover **436** may have a substantially circular in shape. In a non-limiting example, the braking assembly cover **782** may be integrally connected to the flange portion **422** of the gear assembly housing **360** and/or to the gear housing cover **436** by using one or more mechanical fasteners, one or more adhesives, one or more welds and/or a threaded connection.

FIG. **8** is a schematic top-plan view of the axle assembly **300** illustrated in FIGS. **6**-**7**B of the disclosure having a modular electric axle head assembly **802** according to another embodiment of the disclosure. The axle assembly **300** and modular electric axle head assembly **802** illustrated in FIG. **8** are the same as the axle assembly and modular electric axle head assemblies **302** and **702** illustrated in FIGS. **6**-**7**B, except where specifically noted below. In accordance with the embodiment of the disclosure illustrated in FIG. **8** and as a non-limiting example, the modular electric axle head assembly **802** does not include the use of a brake assembly **701**.

As illustrated in FIG. **8** of the disclosure, integrally connected to at least a portion of the first end portion **704** of the first gear shaft **700** is a brake assembly **801**.

The brake assembly **801** may include a brake drum **804** that may be integrally connected to at least a portion of the first end portion **704** of the first gear shaft **700**. When one or more pistons (not shown) of the brake assembly **801** are actuated, one or more brake pads (not shown) are translated outward to become at least variably frictionally engaged with an interior surface (not shown) of the drum **804** of the brake assembly **801**. By selectively frictionally engaging the brake assembly **801** with the first increased diameter portion **746** of the rotor portion **734**, the amount of rotational energy transmitted to the wheels (not shown) of the vehicle (not

shown) can be reduced and/or eliminated. It is therefore to be understood that the brake assembly **801** may be used to aid in slowing down the vehicle (not shown), stopping the vehicle (not shown) and/or preventing the vehicle (not shown) from moving when parked.

According to an embodiment of the disclosure and as a non-limiting example, the brake assembly **801** may function as a parking brake, a parking mechanism, a service brake and/or an anti-theft mechanism. As a result, it is within the scope of this disclosure that the brake assembly **801** may be used alone or in combination with one or more braking assemblies (not shown) located at the first and/or second wheel end assemblies (not shown).

FIG. **9** is a schematic top-plan view of the axle assembly **300** illustrated in FIGS. **6-8** of the disclosure having a modular electric axle head assembly **902** according to yet another embodiment of the disclosure. The axle assembly **300** and modular electric axle head assembly **902** illustrated in FIG. **9** are the same as the axle assembly and modular electric axle head assemblies **302**, **702** and **802** illustrated in FIGS. **6-8**, except where specifically noted below. In accordance with the embodiment of the disclosure illustrated in FIG. **9** and as a non-limiting example, the modular electric axle head assembly **902** does not include the use of a brake assemblies **701** and **801** illustrated in FIGS. **7-8** of the disclosure.

Extending co-axially with the first gear shaft **700** of the gear assembly **378"** is a parking gear **904** of the brake assembly **901** of the modular electric axle head assembly **902**. The parking gear **904** has an inner surface **906**, an outer surface **908**, a first side **910** and a second side **912**. As best seen in FIG. **9** of the disclosure and as a non-limiting example, at least a portion of the parking gear **904** is disposed outside the hollow interior portion **376** of the gear assembly housing **360** and at least a portion of the parking gear **904** is disposed within the hollow interior portion **376** of the gear assembly housing **360** of the gear assembly **378"**. It is within the scope of this disclosure and as a non-limiting example that the parking gear **904** may be integrally formed as part of the first end portion **704** of the first gear shaft **700** or integrally connected to at least a portion of the first end portion **704** of the first gear shaft **700** by using one or more welds, one or more mechanical fasteners, on or more adhesives, a spline connection and/or a threaded connection.

In accordance with the embodiment illustrated in FIG. **9** and as a non-limiting example, an axially extending portion **922** extends ally outward from at least a portion of the second side **912** of the parking gear **904**. As best seen in FIG. **9** of the disclosure and as a non-limiting example, at least a portion of the axially extending portion **922** of the parking gear **904** is disposed within the hollow interior portion **376** of the gear assembly housing **360**. It is within the scope of this disclosure and as a non-limiting example that the axially extending portion **922** of the parking gear **904** may aid in sealing the opening **722** in the gear housing cover **436**. This aids in preventing the migration of dirt, debris and/or moisture into the gear assembly **378"** thereby aiding in improving the overall life and durability of the modular electric axle head assembly **902**.

Circumferentially extending from at least a portion of the outer surface **908** of the parking gear **904** is a plurality of parking gear teeth **914**. The plurality of parking gear teeth **914** are selectively engagable with at least a portion of one or more teeth **916** on a parking pawl **918**. When the parking pawl **918** is in the first position **920** illustrated in FIG. **9** of the disclosure and as a non-limiting example, the one or more teeth **916** of the parking pawl **918** are not meshingly engaged with the plurality of parking gear teeth **914** on the parking gear **904** of the brake assembly **901**. As a result, when the parking pawl **918** is in the first position **920**, the motor **356** is able to drive the first gear shaft **700** which in turn provides the rotational power needed to drive the first and second axle half shafts **319** and **333** of the axle assembly **300**. When the parking pawl **918** is in a second position (not shown) and as a non-limiting example, at least a portion of the one or more teeth **916** of the parking pawl **918** are meshingly engaged with the plurality of parking gear teeth **914** on the parking gear **904**. As a result, when the parking pawl **918** is in the second position (not shown) the motor **356** is unable to drive the first gear shaft **700** and therefore cannot provide the rotational power needed to drive the first and second axle half shafts **319** and **333**. It is therefore within the scope of this disclosure that the brake assembly **901** may function as an anti-theft mechanism, a parking brake, a parking mechanism and/or a service brake. As a result, the brake assembly **901** may be used alone or in combination with the one or more braking assemblies (not shown) located at the first and/or second wheel end assemblies (not shown).

In order to selectively transition the parking pawl **918** between the first position **920** and the second position (not shown), at least a portion of the parking pawl **918** may be connected to at least a portion of an actuation mechanism (not shown). It is within the scope of this disclosure and as a non-limiting example, that the actuation mechanism (not shown) may be an actuator, a linear actuator, a cam actuation mechanism, an electro-magnetic actuator and/or an electro-mechanical actuation mechanism.

According to an embodiment of the disclosure (not shown) and as a non-limiting example, the brake assembly **901** illustrated in FIG. **9** may be used in place of the brake assemblies **701** and **801** or in combination with either the brake assemblies **701** and **801**.

In accordance with the embodiment illustrated in FIG. **9** and as a non-limiting example, the plurality of gear teeth **732**, **502** and **508** on the first, second and third gears **728**, **498** and **510** may be a plurality of helical gear teeth. The helix angle (not shown) of the plurality of gear teeth **732**, **502** and **508** on the first, second and third gears **728**, **498** and **510** may be precisely tuned in order to provide the canceling force vectors needed to reduce, minimize or eliminate the amount of axial forces experienced by the second gear shaft **480** and/or the one or more third and fourth bearing assemblies **488** and **494** of the gear assembly **378"**. As a result, the one or more third and fourth bearing assemblies **488** and **494** may be one or more cylindrical roller bearings. By making the one or more third and fourth bearing assemblies **488** and **494** one or more cylindrical roller bearings, it allows the gear assembly housing **360** to be more compact which reduces the overall weight and improves the packaging of the modular electric axle head assembly **902**. This aids in improving the overall energy/fuel efficiency of the vehicle (not shown) and allows the modular electric axle head assembly **902** to be incorporated into a wider array of vehicles. Additionally, by making the one or more third and fourth bearing assemblies **488** and **494** one or more cylindrical roller bearings, it reduces the noise, vibration and harshness (NVH) characteristics, improves the overall manufacturability and reduces the overall manufacturing/assembly costs associated with the modular electric axle head assembly **902**. Furthermore, by making the one or more third and fourth bearing assemblies **488** and **494** one or more cylindrical roller bearings, it reduces the overall weight and costs associated with the manufacture/assembly of the

modular electric axle head assembly **902** by eliminating the need for and assembly of one or more shims into the modular electric axle head assembly **902**.

In order to axially restrain the parking gear **904** on the first gear shaft **700** of the gear assembly **378"** the nut **768** and a washer **770** may be used. It is to be understood that the nut **768** and a washer **770** aid in preventing the parking gear **904** from becoming disengaged with the first gear shaft **700** when the modular electric axle head assembly **902** is in operation.

FIG. **10** is a schematic top-plan view of a modular electric axle head assembly **1002** according to still yet another embodiment of the disclosure. The axle assembly **300** and the modular electric axle head assembly **1002** illustrated in FIG. **10** is the same as the axle assembly **300** and the modular electric axle head assemblies **302**, **702**, **802** and **902** illustrated in FIGS. **6-9**, except where specifically noted below. In accordance with the embodiment illustrated in FIG. **10** and as a non-limiting example, the modular electric axle head assembly **1002** does not include the use of the gear housing cover **436** described and illustrated in relation to FIGS. **6-9** of the disclosure.

As best seen in FIG. **10** of the disclosure and as a non-limiting example, the modular electric axle head assembly **1002** includes the use of a gear housing cover **436'**. The gear housing cover **436'** illustrated in FIG. **10** is the same as the gear housing cover **436** illustrated in FIGS. **6-9**, except where specifically noted below. According to the embodiment illustrated in FIG. **10** and as a non-limiting example, the gear housing cover **436'** may include a brake assembly receiving portion **1004**. In accordance with the embodiment illustrated in FIG. **10** and as a non-limiting example, the brake assembly receiving portion **1004** extends axially inward from at least a portion of the first side **438** of the gear housing cover **436'**. As a non-limiting example, the brake assembly receiving portion **1004** may be of a size and shape to receive and/or retain at least a portion of the brake assembly **901**. It is within the scope of this disclosure and as a non-limiting example that at least a portion of the parking gear **904**, the parking pawl **918** and/or the actuation mechanism (not shown) of the brake assembly **901** may be received and/or retained within the brake assembly receiving portion **1004** of the gear housing cover **436'**.

Disposed directly adjacent to at least a portion of the first side **438** of the gear housing cover **436'** is a brake assembly cover **1006** having a first side **1008** and a second side **1010**. The brake assembly cover **1006** and the gear housing cover **436'** provide a housing for at least a portion of the brake assembly **901** of the modular electric axle head assembly **1002**. As a result, it is therefore to be understood that the brake assembly cover **1006** aids in preventing the migration of dirt, debris and/or moisture into the gear assembly **278"** and the brake assembly **901** thereby aiding in improving the overall life and durability of the modular electric axle head assembly **1002**. It is within the scope of this disclosure and as a non-limiting example that at least a portion of the brake assembly cover **1006** may be integrally connected to at least a portion of the gear housing cover **436'** by using one or more welds, one or more mechanical fasteners, one or more adhesives and/or a threaded connection.

Extending inward from at least a portion of the second side **1010** of the brake assembly cover **1006** and into the brake assembly cover **1006** is a first receiving portion **1012**. The first receiving portion **1012** of the brake assembly cover **1006** is of a size and shape to receive and/or retain at least a portion of the brake assembly **901** of the modular electric axle head assembly **1002**. As a result, it is within the scope of this disclosure and as a non-limiting example, that at least a portion of the parking gear **904**, the parking pawl **918** and/or the actuation mechanism (not shown) may be disposed within the first receiving portion **1012** of the brake assembly cover **1006**.

In accordance with the embodiment illustrated in FIG. **10** and as a non-limiting example, a second receiving portion **1014** extends inward into the brake assembly cover **1006** from at least a portion of an innermost surface **1016** of the first receiving portion **1012** of the brake assembly cover **1006**. The second receiving portion **1014** of the brake assembly cover **1006** may be of a size and shape to receive and/or retain at least a portion of the first end portion **704** of the first gear shaft **700**, the nut **768** and/or the washer **770** of the modular electric axle head assembly **1002**.

FIGS. **11-11**B provide a schematic illustration of a modular electric axle head assembly **1102** according to still even yet a further embodiment of the disclosure. The axle assembly **300** and the modular electric axle head assembly **1102** illustrated in FIGS. **11-1**B is the same as the axle assembly **300** and modular electric axle head assemblies **302**, **702**, **802**, **902** and **1002** illustrated in FIGS. **6-10**, except where specifically noted below. In accordance with the embodiment illustrated in FIGS. **11-1**B of the disclosure and as a non-limiting example, the modular electric axle head assembly **1102** does not include the first gear shaft **446** or **700** described and illustrated in relation to FIGS. **6-10**. Additionally, in accordance with the embodiment illustrated in FIGS. **11-11**B and as a non-limiting example, the modular electric axle head assembly **1102** does not include the motor mounting member **392** and the gear assembly housing **360** described and illustrated in relation to FIGS. **6-10** of the disclosure.

As best seen in FIG. **11** of the disclosure and as a non-limiting example, the modular electric axle head assembly **1102** includes a gear assembly **378'"**. The gear assembly **378'"** illustrated in FIGS. **11-11**B is the same as the gear assemblies **378**, **378'** and **378"** illustrated in FIGS. **6-10**, except where specifically noted below. According to the embodiment illustrated in FIG. **11** and as a non-limiting example, the gear assembly **378'"** includes a first gear shaft **1100** having an outer surface **1104**, a first end portion **1106**, a second end portion **1108** and an intermediate portion **1110** interposed between the first end second end portions **1106** and **1108**. In accordance with the embodiment illustrated in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the first end portion **1106** of the first gear shaft **1100** extends through or is disposed within an opening **1112** extending from the inner surface **362** to the outer surface **364** of the inboard portion **370** of the first end **426** of a gear assembly housing **360'**. At least a portion of the first end portion **1106** of the first gear shaft **1100** is rotationally supported by the one or more first bearing assemblies **454** interposed between the outer surface **1104** of the first gear shaft **1100** and a surface **1114** defining the opening **1112**.

Disposed directly adjacent to at least a portion of the first end **426** of the gear assembly housing **360'** is a gear housing cover **1116** having a first side **1118** and a second side **1120**. The gear housing cover **1116** is of a size and shaft to seal the opening **1112** in the first end **426** of the gear assembly housing **360'**. As a result, it is to be understood that the gear housing cover **1116** aids in preventing the migration of dirt, debris and/or moisture into the gear assembly **378'"** thereby aiding in improving the overall life and durability of the gear assembly **378'"**. It is within the scope of this disclosure and as a non-limiting example that the hear housing cover **1116** may be integrally connected to at least a portion of the first

end **426** of the gear assembly housing **360'** by using one or more welds, one or more mechanical fasteners, one or more adhesives and/or a threaded connection.

Extending inward into at least a portion of the second side of the **1120** of the gear housing cover **1116** is a receiving portion **1122**. The receiving portion **1122** is of a size and shape to receive and/or retain at least a portion of the first end portion **1106** of the first gear shaft **1100** of the gear assembly **378'"**.

It is within the scope of this disclosure and as a non-limiting example that at least a portion of the second side **1120** of the gear housing cover **1116** may be in direct contact with at least a portion of the one or more first bearing assemblies **454** of the gear assembly **378'"**. As a result, it is to be understood that the gear housing cover **1116** may be precisely engineered in order to provide the pre-tensioning force and/or clearance needed for optimal operation of the one or more first bearing assemblies **454**.

Connected to at least a portion of the outer surface **1104** of the first end portion **1106** of the first gear shaft **1100** is a first gear **1124**. Circumferentially extending from at least a portion of an outer surface **1126** of the first gear **1124** is a plurality of first gear teeth **1128**. According to an embodiment of the disclosure and as a non-limiting example, the first gear **1124** may be integrally formed as part of the first end portion **1106** of the first gear shaft **1100**. The plurality of first gear teeth **1128** are complementary to and meshingly engaged with the plurality of second gear teeth **502** on the second gear **498** of the gear assembly **378'"**. In accordance with an alternative embodiment of the disclosure and as a non-limiting example, the first gear **1124** may be integrally connected to at least a portion of the first end portion **1106** of the first gear shaft **1100** by using one or more adhesives, one or more mechanical fasteners, one or more welds, a threaded connection and/or a splined connection. It is within the scope of this disclosure and as a non-limiting example that the first gear **1124** may be a first reduction gear for the gear assembly **378'"** of the modular electric axle head assembly **1102**. As a non-limiting example, the plurality of first gear teeth **1128** extending from the outer surface **1126** of the first gear **1124** may be a plurality of hypoid gear teeth, spiral bevel gear teeth, helical gear teeth, spur gear teeth, double hypoid gear teeth, double spiral bevel gear teeth or double helical gear teeth.

According to the embodiment illustrated in FIG. **11** and as a non-limiting example, an opening **1130** may extend from the inner surface **362** to the outer surface **364** of the second end **428** of the gear assembly housing **360'**. As best seen in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the second end portion **1108** of the first gear shaft **1100** and/or at least a portion of the second end portion **484** of the second gear shaft **480** is disposed within or extends through the opening **1130** in the gear assembly housing **360'**.

Disposed directly adjacent to at least a portion of the second end **428** of the gear assembly housing **360'** is a motor mounting member **1132** having a first side **1134**, a second side **1136**, an inboard portion **1138** and an outboard portion **1140**. In accordance with the embodiment illustrated in FIG. **11** of the disclosure and as a non-limiting example, motor mounting member **1132** may have a size and shape needed to completely cover the opening **1130** in the second end **428** of the gear assembly housing **360'**. As a result, it is therefore to be understood that the motor mounting member **1132** may aid in preventing the migration of dirt, debris and/or moisture into the gear assembly **378'"** of the modular electric axle head assembly **1102**.

Integrally connected to at least a portion of the second side **1136** of the motor mounting member **1132** is the motor **356** of the modular electric axle head assembly **1102**. It is within the scope of this disclosure and as a non-limiting example that the motor **356** may be integrally connected to the motor mounting member **1132** by using one or more welds, one or more mechanical fasteners, one or more adhesives, a spline connection and/or a threaded connection.

As best seen in FIG. **11** of the disclosure and as a non-limiting example, at least a portion the motor output shaft **358** of the motor **356** is drivingly connected to at least a portion of the second end portion **1108** of the first gear shaft **1100**. According to the embodiment illustrated in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the motor output shaft **358** may be received and/or retained within at least a portion of a hollow portion **1144** extending inward from an end of the first shaft **1100**. It is within the scope of this disclosure and as a non-limiting example that the motor output shaft **358** may be drivingly connected to the first gear shaft **1100** by using one or more welds, one or more mechanical fasteners, one or more adhesives, a splined connection and/or a threaded connection.

Extending from the first side **1134** to the second side **1136** in the inboard portion **1138** of the motor mounting member **1132** of the gear assembly **378'"** is an opening **1142**. The opening **1142** of the motor mounting member **1132** may be of a size and shape to receive and/or retain at least a portion of the second end portion **1108** of the first gear shaft **1100** and/or at least a portion of the motor output shaft **358**. In accordance with the embodiment illustrated in FIG. **11** and as a non-limiting example, at least a portion of the one or more second bearing assemblies **478** providing rotational support for the first gear shaft **1100** and/or the motor output shaft **358** may be interposed between the outer surface **1104** of the first gear shaft **1100** and a surface **1146** defining the opening **1142** of the motor mounting member **1132**.

Integrally connected to at least a portion of the outer surface of the second end portion **1108** of the first gear shaft **1100** is a parking gear **1148** of the brake assembly **1101**. As best seen in FIG. **11** of the disclosure and as a non-limiting example, the parking gear **1148** has an inner surface **1150** and an outer surface **1152**. At least a portion of the inner surface **1150** of the parking gear **1148** is integrally connected to at least a portion of the outer surface **1104** of the second end portion **1108** of the first gear shaft **1100**. It is within the scope of this disclosure and as a non-limiting example, that the parking gear **1148** may be integrally formed as part of the first gear shaft **1100** or integrally connected to at least a portion of the first gear shaft **1100** by using one or more welds, one or more mechanical fasteners, one or more adhesives, a spline connection and/or a threaded connection.

Circumferentially extending from at least a portion of the outer surface **1152** of the parking gear **1148** is a plurality of parking gear teeth **1154**. As best seen in FIG. **11**B of the disclosure and as a non-limiting example, the plurality of parking gear teeth **1154** are selectively engagable by one or more teeth **1156** of a parking pawl **1158** of the brake assembly **1101**. When the parking pawl **1158** is in a first position (not shown), the one or more teeth **1156** of the parking pawl **1158** are not meshingly engaged with the plurality of parking gear teeth **1154** on the outer surface **1152** of the parking gear **1148**. As a result, when the parking pawl **1158** is in the first position (not shown), the motor **356** is able to provide the rotational power needed to drive the first gear shaft **1100** and therefore the first and second axle half shaft **319** and **333** of the modular electric axle head assembly

11002. When the parking pawl **1158** is in a second position **1160** illustrated in FIG. **11**B of the disclosure, the one or more teeth **1156** of the parking pawl **1158** are meshingly engaged with the plurality of parking gear teeth **1154** on the parking gear **1148**. As a result, when the parking pawl **1158** is in the second position **1160**. As a result, when the parking pawl **1158** is in the second position **1160** the motor **356** is unable to drive the first gear shaft **1100** and therefore cannot provide the rotational power needed to drive the first and second axle half shafts **319** and **333**. It is therefore within the scope of this disclosure that the brake assembly **1101** may function as an anti-theft mechanism, a parking brake, a parking mechanism and/or a service brake. As a result, the brake assembly **1101** may be used alone or in combination with the one or more braking assemblies (not shown) located at the first and/or second wheel end assemblies (not shown) and/or in combination with the brake assemblies **701**, **801** and/or **901** described herein.

In order to selectively transition the parking pawl **1158** between the first position (not shown) and the second position **1160**, at least a portion of the parking pawl **1158** may be connected to at least a portion of an actuation mechanism **1162**. It is within the scope of this disclosure and as a non-limiting example, that the actuation mechanism **1162** may be an actuator, a linear actuator, a cam actuation mechanism, an electro-magnetic actuator and/or an electro-mechanical actuation mechanism.

According to an embodiment of the disclosure (not shown) and as a non-limiting example, the brake assembly **1101** illustrated in FIGS. **11** and **11**B may be used in place of the brake assemblies **701** and **801** or in combination with either the brake assemblies **701** and **801** described and illustrated in relation to FIGS. **7-8**.

In order to aid in the assembly of the brake assembly **1101** of the modular electric axle head assembly **1102**, the gear assembly housing **360'** may further include a brake assembly aperture **1164** extending from the inner surface **362** to the outer surface **364** of the gear assembly housing **360'**. The brake assembly aperture **1164** may be of a size and shape to receive and/or retain at least a portion of an assembly tool **1166** having first end portion **1168** and a second end portion **1170**. As best seen in FIGS. **11**A and **11**B of the disclosure and as a non-limiting example, at least a portion of the first end portion **1168** of the assembly tool **1166** has a size and shape that is complementary to the size and shape of the brake assembly aperture **1164** in the gear assembly housing **360'**.

When the first end portion **1168** of the assembly tool **1166** is inserted within the brake assembly aperture **1164**, at least a portion of one or more legs **1172** of the first end portion **1168** of the assembly tool **1166** is in direct contact with at least a portion of the inner surface **362** of the gear assembly housing **360'** thereby preventing the assembly tool **1166** from exiting the hollow interior portion **378** of the gear assembly housing **360'**. As the assembly tool **1166** is inserted within the brake assembly aperture **1164** at least a portion of the first end portion **1168** of the assembly tool **1166** is driven into direct contact with at least a portion of the parking pawl **1158** thereby driving the parking pawl **1158** toward engagement with the parking gear **1148**. As the parking pawl **1158** is driving into engagement with the parking gear **1148**, a spring **1174** connected to at least a portion of the parking pawl **1158** and the gear assembly housing **360'** is loaded with an amount of energy. When the one or more legs **1172** of the assembly tool **1166** are in contact with the inner surface **362** of the gear assembly housing **360'**, the parking pawl **1158** is in the second position **1160** providing the space needed to assemble the actuation mechanism **1162** within with gear assembly **378'''**. As a result, it is therefore to be understood that the assembly tool **1166** aids in facilitating the assembly of the brake assembly **1101** of the modular electric axle head assembly **1102**.

According to the embodiment illustrated in FIG. **11** the inner surface **362** of the outboard portion **372** of the first end portion **366** of the gear assembly housing **360'** is a receiving portion **1176**. It is within the scope of this disclosure and as a non-limiting example that the receiving portion **1176** may be of a size and shape needed to receive and/or retain at least a portion of the first end portion **482** of the second gear shaft **480** of the gear assembly **378'''**. As best seen in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the one or more third bearing assemblies **488** are interposed between a surface **1178** defining the recessed portion **1176** and the outer surface **486** of the first end portion **482** of the second gear shaft **480**.

In accordance with the embodiment illustrated in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the outboard portion **1140** of the first side **1134** of the motor mounting member **1132** is a receiving portion **1180**. The receiving portion **1180** is of a size and shape to receive and/or retain at least a portion of the second end portion **484** of the second gear shaft **480** of the gear assembly **378'''**. As best seen in FIG. **11** of the disclosure and as a non-limiting example, at least a portion of the one or more fourth bearing assemblies **494** are interposed between a surface **1182** defining the receiving portion **1180** and the outer surface **486** of the second end portion **484** of the second gear shaft **480**.

FIG. **12** is a schematic perspective view of a portion of the modular electric axle head assembly **1202** illustrated in FIGS. **6-11**B having a motor stabilizing assembly **1204** according to an embodiment of the disclosure. The modular electric axle head assembly **1202** illustrated in FIG. **12** is the same as the modular electric axle head assemblies **302**, **702**, **802**, **902**, **1002** and **1102** illustrated in FIGS. **6-11**B, except where specifically noted below. At least a portion of the motor stabilizing assembly **1204** is integrally connected to at least a portion of the motor **356** and the second axle half shaft housing **306** of the axle assembly **300**. It is therefore to be understood that the motor stabilizing assembly **1204** aids in providing support to the motor **356** thereby improving the overall life and durability of the modular electric axle head assembly **1202**.

As best seen in FIG. **12** of the disclosure and as a non-limiting example the motor stabilizing assembly **1204** may include a first portion **1206**, a second portion **1208** and a third portion **1210**. It is within the scope of this disclosure and as a non-limiting example that the first portion **1206** of the motor stabilizing assembly **1204** may be integrally formed as part of the motor **356** or may be integrally connected to at least a portion of the motor **356** by using one or more welds, one or more mechanical fasteners and/or one or more adhesives. Additionally, as best seen in FIG. **12** of the disclosure and as a non-limiting example, at least a portion of the second portion **1208** of the motor stabilizing assembly **1204** may be integrally formed as part of the second axle half shaft housing **306** or integrally connected to at least a portion of the second axle half shaft housing **306** by using one or more welds, one or more adhesives and/or one or more adhesives.

In accordance with the embodiment illustrated in FIG. **12** of the disclosure and as a non-limiting example, at least a portion of the third portion **1210** of the motor stabilizing assembly **1204** is integrally connected to at least a portion of

the first portion **1206** of the motor stabilizing assembly **1204**. Additionally, in accordance with the embodiment illustrated in FIG. **12** and as a non-limiting example, at least a portion of the third portion **1210** of the motor stabilizing assembly **1204** is integrally connected to at least a portion of the second portion **1208** of the motor stabilizing assembly **1204**. It is within the scope of this disclosure and as a non-limiting example that the third portion **1210** of the motor stabilizing assembly **1204** may be integrally connected to the first and second portion **1206** and **1208** of the motor stabilizing assembly **1204** by using one or more welds, one or more mechanical fasteners and/or one or more adhesives.

FIG. **13** is a schematic perspective view of a portion of a modular electric axle head assembly **1302** having a strain relief member **1304** according to an embodiment of the disclosure. The modular electric axle head assembly **1302** illustrated in FIG. **13** is the same as the modular electric axle head assemblies **302**, **702**, **802**, **902**, **1002**, **1102** and **1202** illustrated in FIGS. **6-12**, except where specifically noted below. As illustrated in FIG. **13** of the disclosure and as a non-limiting example, at least a portion of the strain relief member **1304** is integrally connected to at least a portion of the motor mounting member **1132** of the modular electric axle head assembly **1302**.

In accordance with the embodiment illustrated in FIG. **13** of the disclosure and as a non-limiting example, the strain relief member **1304** includes one or more retention apertures **1306**. The one or more retention apertures **1306** are of a size and shape needed to receive and retain at least a portion of one or more terminals or data links **1308** needed to operate and/or control the motor **356** of the modular electric axle head assembly **1302**. It is to be understood that the strain relief member **1304** provides the support needed in order to ensure that the one or more terminals or data links **1308** are not damaged or become prematurely disconnected from the motor **356**. As a result, the strain relief member **1304** aids in improving the overall life and durability of the modular electric axle head assembly **1302** and the one or more terminals or data links **1308**.

It is to be understood that the various embodiments described in this specification and as illustrated in the attached drawings are simply exemplary embodiments illustrating the inventive concepts as defined in the claims. As a result, it is to be understood that the various embodiments described and illustrated may be combined to from the inventive concepts defined in the appended claims.

In accordance with the provisions of the patent statutes, the present invention has been described to represent what is considered to represent the preferred embodiments. However, it should be note that this invention can be practiced in other ways than those specifically illustrated and described without departing from the spirit or scope of this invention.

What is claimed is:

1. A modular electric axle head assembly, comprising:

an axle assembly having a banjo portion with an inner surface, an outer surface, an inboard side and an outboard side;

a first opening extends from said inner surface to said outer surface of said inboard side of said banjo portion of said axle assembly;

a differential assembly having a differential case disposed within at least a portion of said banjo portion;

a gear assembly drivingly connected to at least a portion of said differential assembly;

a motor having a motor output shaft that is drivingly connected to at least a portion of said gear assembly;

a gear assembly housing having an inboard portion, an outboard portion, an inner surface an outer surface defining a hollow portion therein;

wherein said outboard portion of said gear assembly housing has an axle assembly mounting flange integrally connected to at least a portion of said inboard side of said banjo portion;

a parking pawl that is selectively engagable with a parking gear by using an actuation mechanism;

wherein a brake assembly aperture extends from said inner surface to said outer surface of said gear assembly housing;

wherein said brake assembly aperture has a size and shape to receive and retain at least a portion of an assembly tool; and

wherein when said assembly tool is disposed within said gear assembly housing, at least a portion of a first end portion of said assembly tool drives said parking pawl into engagement with said parking gear.

2. The modular electric axle head assembly of claim **1**, wherein said gear assembly comprises:

said first'gear shaft having a first gear;

a second gear shaft having a second gear and a third gear;

wherein at least a portion of said second gear is drivingly connected to said first gear of said gear assembly; and

wherein at least a portion of said third gear is drivingly connected to at least a portion of a ring gear of said differential assembly.

3. The modular electric axle head assembly of claim **2**, wherein said first gear has a plurality of first gear teeth;

wherein said second gear has a plurality of second gear teeth;

wherein said third gear has a plurality of third gear teeth; and

wherein said plurality of first gear teeth, said plurality of second gear teeth and said plurality of third gear teeth have a helix angle that reduces or eliminates an amount of axial force experienced by said second gear shaft of said gear assembly when in operation.

4. The modular electric axle head assembly of claim **2**, wherein said gear assembly housing further comprises an opening extending from said inner surface to said outer surface of said inboard portion of a first end of said gear assembly housing;

wherein said opening in said inboard portion of said first end of said gear assembly housing provides rotational support for at least a portion of a first end portion of said first gear shaft; and

wherein at least a portion of one or more first bearing assemblies are interposed between an outer surface of said first end portion of said first gear shaft and a surface defining said opening in said inboard portion of said first end of said gear assembly housing.

5. The modular electric axle head assembly of claim **1**, further comprising a gear housing cover having a first side and a second side;

wherein said gear housing cover has a size and shape to seal said opening in said inboard portion of said first end of said gear assembly housing; and

wherein at least a portion of said gear housing cover is integrally connected to at least a portion of said first end of said gear assembly housing.

6. The modular electric axle head assembly of claim **5**, wherein at least a portion of said second side of said gear housing cover is in direct contact with at least a portion of said one or more first bearing assemblies.

7. The modular electric axle head assembly of claim 5, wherein said gear housing cover further comprises a receiving portion in said second side of said gear housing cover; and

wherein said reviving portion in said second side of said gear housing cover is of a size and shape to receive and/or retain at least a portion of said first end portion of said a first gear shaft of said gear assembly.

8. The modular electric axle head assembly of claim 1, wherein said gear assembly housing further comprises a receiving portion in said inner surface of said outboard portion of a first end portion of said gear assembly housing; and

wherein at least a portion of one or more third bearing assemblies are interposed between an outer surface of a first end portion of said second gear shaft and a surface defining said receiving portion in said inner surface of said outboard portion of said first end portion of said gear assembly housing.

9. The modular electric axle head assembly of claim 1, further comprising a motor mounting member having a first side, a second side, an inboard portion and an outboard portion;

wherein at least a portion of said first side of said motor mounting member is integrally connected to at least a portion of a second end of said gear assembly housing;

wherein at least a portion of said second side of said motor mounting member includes a motor mounting portion;

wherein at least a portion of said motor is mounted to said motor mounting portion of said motor mounting member;

wherein a motor mounting member opening extends from said first side to said second side of said motor mounting member; and

wherein at least a portion of said motor output shaft extends through said motor mounting member opening.

10. The modular electric axle head assembly of claim 9, wherein said motor mounting member opening is of a size and shape provide rotational support for at least a portion of a second end portion of said first gear shaft and said motor output shaft; and

wherein at least a portion of one or more second bearing assemblies are interposed between an outer surface of said second end portion of said first gear shaft and a surface defining said motor mounting member opening.

11. The modular electric axle head assembly of claim 9, wherein said motor mounting member further comprises a receiving portion in said first side of said outboard portion of said motor mounting member;

wherein at least a portion of one or more fourth bearing assemblies are interposed between an outer surface of said second end portion of said second gear shaft and a surface defining said receiving portion of said motor mounting member.

12. The modular electric axle head assembly of claim 2, wherein said one or more third bearing assemblies rotationally supporting an end of said second gear shaft are one or more cylindrical roller bearing assemblies; and

wherein one or more fourth bearing assemblies rotationally supporting an end of said of said second gear shaft opposite said one or more third bearing assemblies are one or more cylindrical roller bearing assemblies.

13. The modular electric axle head assembly of claim 1, further comprising a brake assembly.

14. The modular electric axle head assembly of claim 1, wherein a first protruding portion and a second protruding portion extend from said axle assembly mounting flange of said gear assembly housing; and

wherein at least a portion of said first protruding portion and said second protruding portion provide rotational support for at least a portion of said differential case of said differential assembly.

15. The modular electric axle head assembly of claim 1; wherein when said assembly tool is disposed within said gear assembly housing and has driven drives said parking pawl into engagement with said parking gear an amount of space needed to assemble said actuation mechanism into within said gear assembly is provided.

16. The modular electric axle head assembly of claim 1, further comprising a brake assembly comprising a rotor portion and a caliper assembly that is selectively engagable with said rotor portion of said brake assembly; and

wherein at least a portion of said rotor portion of said brake assembly is integrally drivingly connected to at least a portion of said first gear shaft of said gear assembly.

17. The modular electric axle head assembly of claim 16, further comprising a braking assembly cover; and

wherein at least a portion of said braking assembly cover encases at least a portion of said rotor portion and said caliper assembly of said brake assembly.

18. The modular electric axle head assembly of claim 13, wherein said brake assembly is a drum brake assembly that is drivingly connected to at least a portion of said first gear shaft.

19. The modular electric axle head assembly of claim 9, further comprising a strain relief member integrally connected to at least a portion of said motor mounting member;

wherein said strain relief member has one or more retention apertures; and

wherein said one or more retention apertures are of a size and shape to receive and/or retain at least a portion of one or more terminals or data links used in said operation and/or control of said motor.

20. The modular electric axle head assembly of claim 1, further comprising a motor stabilizing assembly; and

wherein at least a portion of said motor stabilizing assembly is integrally connected to at least a portion of said motor and an axle half shaft housing of said axle assembly.

21. The modular electric axle head assembly of claim 2, further comprising a gear housing cover having a first side, a second side, an inboard portion and an outboard portion;

wherein at least a portion of said gear housing cover is integrally connected to at least a portion of a first end of said gear assembly housing;

wherein said inboard portion of said second side of said gear housing cover has a first receiving portion and said outboard portion of said second side of said gear housing cover has a second receiving portion;

wherein at least a portion of said first end portion of said first gear shaft is received within at least a portion of one or more first bearing assemblies disposed within said first receiving portion of said gear housing cover; and

wherein at least a portion of a first end portion of said second gear shaft is received within one or more third bearing assemblies disposed within at least a portion of said second receiving portion of said gear housing cover.

22. The modular electric axle head assembly of claim 21, wherein said gear assembly housing further comprises a

receiving portion in said inner surface of said outboard portion of said second end portion of said gear assembly housing; and

wherein at least a portion of a second end portion of said second gear shaft is received within one or more fourth bearing assemblies disposed within at least a portion of said receiving portion in said inner surface of said outboard portion of said second end portion of said gear assembly housing.

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